# Measurement of Wireless Service Quality in Guest House of NIT Rourkela

***A PROJECT REPORT***

*Submitted in partial fulfillment of the requirements for the degree*
*of*
*Bachelor of Technology*
*in*
*Electronics and Instrumentation Engineering*

*by*


***Satyajit Mahapatro***
Roll No. - 10407018
&
***Punit Thacker***
Roll No. - 10407022


*Under the guidance*
*of*
***Dr. S.K.Patra***


**Department of Electronics & Communication Engineering**
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# CERTIFICATE

This is to certify that the thesis entitled **"Measurement of Wireless Service Quality in Guest House of NIT Rourkela''** submitted by **Satyajit Mahapatro (Roll No: 10407018) and Punit Thacker (Roll No: 10407022)** in the partial fulfillment of the requirement for the degree of **Bachelor of Technology** in **Electronics And Instrumentation Engineering, National Institute of Technology, Rourkela,** is an authentic work carried out by them under my supervision.

To the best of my knowledge the matter embodied in the thesis has not been submitted to any other university/ institute for the award of any degree or diploma.

**Dr. S.K.Patra**
Department of Electronics and Communication Engineering
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# ACKNOWLEDGEMENT

We take this opportunity as a privilege to thank all individuals without whose support and guidance we could not have completed our project in this stipulated period of time.

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# CONTENTS

## Abstract
Wireless Local Area Networks (WLANS) have emerged as an untethered alternative for access networks. There is a strong and growing demand of WLANS in consumer markets and industrial markets such as health, education, airports etc. Currently our Institute is also planning for wireless connectivity in the campus area. By using Network Simulation Software such as Qualnet[1], the performance of wireless networks[3] in a scenario ( building or campus) can be studied. By loading the blueprint of the scenario (building or campus) propagation modeling techniques can now predict user data throughput based on radio signal strength In this paper we have performed detailed simulations of measurement of wireless service quality in the Guest House of NIT Rourkela. The Autocad drawing of Guest House was studied and a realistic scenario was created in Qualnet placing the different nodes in various lacations. The throughput measurement using different number of access points and for different applications (FTP, Streaming Audio) is studied. The number of access points were varied from 1 to 4 and the file size for FTP applications was also varied till a saturated value of throughput was obtained. By laying out the blueprint of the scenario in network modeling softwares such as Qualnet[1] wireless local area networks can be planned effectively and their performance can be studied exhaustively.

# List of Figures

# CHAPTER 1

# INTRODUCTION

## INTRODUCTION-Wireless LAN

Wireless computing is a rapidly emerging technology providing users with network connectivity without being tethered off of a wired network. Wireless local area networks (WLANs), like their wired counterparts, are being developed to provide high bandwidth to users in a limited geographical area. WLANs are being studied as an alternative to the high installation and maintenance costs incurred by traditional additions, deletions, and changes experienced in wired LAN infrastructures. Physical and environmental necessity is another driving factor in favor of WLANs. Typically,new building architectures are planned with network connectivity factored into the building requirements. However, users inhabiting existing buildings may find it infeasible to retrofit existing structures for wired network access. Examples of structures that are very difficult to wire include concrete buildings, trading floors, manufacturing facilities, warehouses, and historical buildings. Lastly, the operational environment may not accommodate a wired network, or the network may be temporary and operational for a very short time, making the installation of a wired network impractical. Examples where this is true include ad hoc networking needs such as conference registration centers, campus classrooms, emergency relief centers, and tactical military environments.

### IEEE 802.11 Physical Layer

The physical layer for IEEE 802.11 has been issued in three stages; the first part was issued in 1997and the remaining two parts in 1999. The first part simply called IEEE 802.11, includes the MAC layer and three physical layer specifications, two in the 2.4 GHZz band and one in the infrared operating at 1 and 2 Mbps. IEEE 802.11a operates in the 5 GHz band at data rates upto 54 Mbps. IEEE 802.11b operates in the 2.4 GHz band at 5.5 and 11 Mbps.

### IEEE 802.11a

The IEEE 802.11a specification makes use of the 5GHz band. Unlike the 2.4 GHz specifications, IEEE 802.11 does not use a spread spectrum scheme but rather uses orthogonal frequency division multiplexing (OFDM). The possible data rates for IEEE 802.11 are 6,9,12,18,24,36,48 and 54 Mbps. The system uses upto 52 subcarriers that are modulated using BPSK, QPSK, 16-QAM or 64-QAM depending on the rate required.

### IEEE 802.11b

IEEE 802.11b specification makes use of the 2.4GHz band. It uses a Direct Sequence Spread Spectrum technique and provides data rates of 1, 2, 5.5 and 11Mbps. The chipping rate is 11MHz. To acieve a higher data rate in the same bandwidth and at the same chipping rate, a modulation scheme known as complementary code Keying(CCK) is used.

To design and deploy a wireless LAN an accurate deployment procedure is required to ensure sufficient coverage and network functionality. While wireless networking gear is often classified according to its standards based Signaling rate, the actual data throughput is much less than or a fraction of the actual signaling rate. Research conducted in [4] showed that the user throughput performance changes rapidly when accesss points or transmitters are located near a interferer. Factors due to which data throughput decreases has been dealt with in the following sections.

The performance of a Wi-Fi home network greatly depends on signal strength of the wireless router or wireless access point (base station). If a given wireless client falls out of range of the base station signal, obviously that network connection will fail or "drop." Clients situated near the edge of the network range will likely experience intermittent dropped connections. But even when a wireless client stays within range consistently, its network performance can still be adversely affected by distance, obstructions, or interference

# CHAPTER 2

# QualNet Simulator

## 2.1 Introduction

QualNet[1] is a fast, scalable and hi-fidelity network modeling software. It enables very efficient and cost-effective development of new network technologies. By building virtual networks in a lab environment, you can test, optimize, and integrate next generation network technologies at a fraction of the cost of deploying physical testbeds.

It is intended for users with a basic understanding of computer networking. It uses the QualNet IDE (Integrated Development Environment) for an integrated network simulation experience for network design, execution and animation and analysis.

QualNet[1] is network modeling software that predicts performance of networking protocols and networks through simulation and emulation. Using emulation and simulation allows you to reproduce the unfavorable conditions of networks in a controllable and repeatable lab setting.

## 2.2 Key Benefits of QualNet

QualNet provides the following key benefits:

• **Speed**. QualNet can support real-time and faster than real-time simulation speed, which enables software-in-the-loop, network emulation, hardware-in-the-loop, and human-in-the-loop exercises.

• **Scalability**. QualNet supports thousands of nodes. It can also take advantage of parallel computing architectures to support more network nodes and faster modeling. Speed and scalability are not mutually exclusive with QualNet.

• **Model Fidelity**. QualNet offers highly detailed models for all aspects of networking. This ensures accurate modeling results and enables detailed analysis of protocol and network performance.

• **Portability.** QualNet runs on a vast array of platforms, including Linux, Solaris, Windows XP, and Mac OS X operating systems, distributed and cluster parallel architectures, and both 32- and 64-bit computing.

• **Extensibility**. QualNet connects to other hardware & software applications, such as OTB, real networks, and STK, greatly enhancing the value of the network model.

## 2.3 QualNet IDE Layout

QualNet's user interface has four tools to provide a complete suite for modeling and analyzing communication networks. These tools can be accessed from the tabs at the top of the window. The four tools in QualNet's user interface are:

• **Scenario Designer** - Scenario Designer enables users to create and modify networking scenarios. It includes a comprehensive set of network components, and links and applications for modeling networks. Users can configure all the elements of a scenario: terrain, mobility, radio type and parameters, and mac, network, transport and application layer protocols.

• **Animator** - Once a scenario is created, Animator allows you to run your simulation and provides various options to 'animate' various network events. It also allows you to control the speed of the simulation to clearly observe and analyze the scenario. We can also use animation filters to control the amount of information displayed.

• **Analyzer** - Analyzer enables graphical analyses of the statistics collected during the simulation. Using per-node and per-protocol model statistics users can better understand the implications of using particular protocols, parameter values and network architecture.

• **Packet Tracer** - Once a simulation scenario has been run or executed, tracing provides per-packet analyses of the simulation. Packet Tracer displays information about packet headers and fields in an organized way.

## 2.4 Designing Scenarios

Scenario Designer enables users to create and modify networking scenarios. It includes a comprehensive set of network components, and links and applications for modeling networks. Scenario Designer provides a GUI interface for creating scenarios, adding nodes to it, modifying the placement of the nodes etc.. For any scenario a config file ,**scenarioname.config** where scenarioname is the name of the scenario. This config file contains all the properties related to the nodes and the environmental settings.

Key features include;

**Node positions-**

The actual position of the nodes in the network. It is represented by a two dimensional coordinate system in x and y coordinate axes.

**Propagation Channel Frequency-**

The frequency of the carrier signal i.e the signal at which the baseband signal will propagate.

**Propagation Limit**

Expressed in dBm. Signals with powers below PROPAGATION-LIMIT (in dBm) are not delivered.

**Propagation Pathloss Model**

Propagation models pedict the signal strength for an arbitrary transmitter receiver separation distance and are useful in determining the radio coverage area of the transmitter.

**Propagation Fading Model**

Small Scale fading models such as Rayleigh fading model

**Phy-Model**

IEEE 802.11 Physical layers: 802.11a, 802.11b

**Data Rate**

The data rates corresponding to the Phy Layer model used.

**Transmitter Power**

In radio transmission, **transmitter power** is the actual amount of power (in watts) of radio frequency (RF) energy that a transmitter produces at its output.

**Reciever Sensitivity**

A receiver's **sensitivity** is a measure of its ability to discern low level signals. Because receive sensitivity indicates how faint a signal can be successfully received by the receiver, the lower power level, the better. This means that the larger the absolute value of the negative number, the better the receive sensitivity. For example, a receive sensitivity of -98 dBm is better than a receive sensitivity of -95 dBm by 3 dB, or a factor of two

**Noise Factor**

The **noise factor**(F) of a device specifies how much additional noise the device will contribute to the noise already from the source.

## 2.5 Shortcomings

Qualnet includes various features for testing the performance of wireless as well as wired networks. Qualnet is designed with IEE 802.11 wireless standard and strongly complies with it. However at the present version of Qualnet, only two pathloss propagation models are inbuilt in Qualnet.- Free Space and Two Ray model. In order to predict actual throughput propagations in realistic environments considering the effect of walls and buildings the propagation model has to be different.

# CHAPTER 3

# WLAN Performance Parameters

## An Overview of Throughput

A WLAN generally consists of an access point(AP) that connects to a wired network and remote devices(client) that connects to the access point through wireless radio links. Throughput[5] is defined as the speed with which the user can send and receive data between the client and the access point. Throughput varies across the WLAN's coverage area. This section describes the main factors that affect WLAN throughput and coverage.

### 3.1 802.11 Protocol:

The IEEE 802.11 defines various physical layer rates for different types of WLANs such as 1,2, 5.5 and 11 Mbps for 802.11b and 802.11g. Rates for 802.11a and 802.11g include 6,9,12,18.24,36,48 and 54 Mbps. The user throughput is less than these link rates for several reasons:

- Each packet includes additional data such as preambles, headers(MAC,IP).
- When every directed(unicast) packet is received the receiver sends a short acknowledgement packet back to the sender.
- Transmitters wait for short random time between packets to allow other users to contend for and share the channel.

### 3.2 The Radio Environment:

Several issues affect the way the radio signal travels from one device to another:

- Radio energy attenuates as it propagates. As radio waves propagate spherically outwards , the energy spreads over an ever-increasing area. In freee space doubling the distance decreases the received power by a factor of 4 – the so called $1/r^2$ behaviour. Radio signals also attenuate when they pass through walls, floors furniture or people.

- Antenna designs affect how much radio frequency is transmitted and received and where it is directed.

- Scattering and multipath cause fading effects. Signal strength can change rapidly as a function of locations because the received signal is the sum of potentially numerous signals scattered from numerous objects. As the transmitter or the objects in the environment move the signals sometimes add and sometimes cancel each other.
- Fading also occurs over time as well as location. Even small changes in the environment (for example people or other objects moving) can affect the fading pattern. This means that the received can quickly change over time even when the transmitter and receiver are fixed.

o Other devices occupying the same or nearby channels cause interference. For example the 2.4 Ghz channel might be occupied by Bluetooth, microwave ovens etc.

## 3.3Frequency:

Effects such as antenna efficiency, RF component performance, absorption through and scattering around objects do depend upon frequency.

o Generally antenna of the same size tend to become more directional (have higher gain in some directions and less in others) as the frequency increases. Advantage 5Ghz

o Absorption due to propagation through objects tends to increase with frequency. Advantage 2.4Ghz.

o Noise and spurs generated by the nearby electronic devices in addition to the co- channel interference will degrade 2.4GHz sensitivity more than the 5GHz sensitivity. Advantage:5GHz.

o Cable loss increases with frequency. Adnvantage:2.4GHz.

# CHAPTER 4

# Overview of Guest House in NIT Rourkela

## Measurement Environment Description:

The figure below shows the physical layout of the measurement environment in the Guest House of NIT Rourkela in NIT campus. The Guest House of NIT Rourkela a one storeyed building spread over an area of 40m*25m. The ground floor and the first floor are similar in structure. Three rooms are there in each floor. The rooms in first floor are just above the rooms in the ground floor. The room dimensions are as follows:

Ground floor:

Room 6: 4.4m*3.8m

Room 5: 4.6m*3.8m

Room 4: 4.6m*3.8m

Dining hall: 10.7m*4.9m

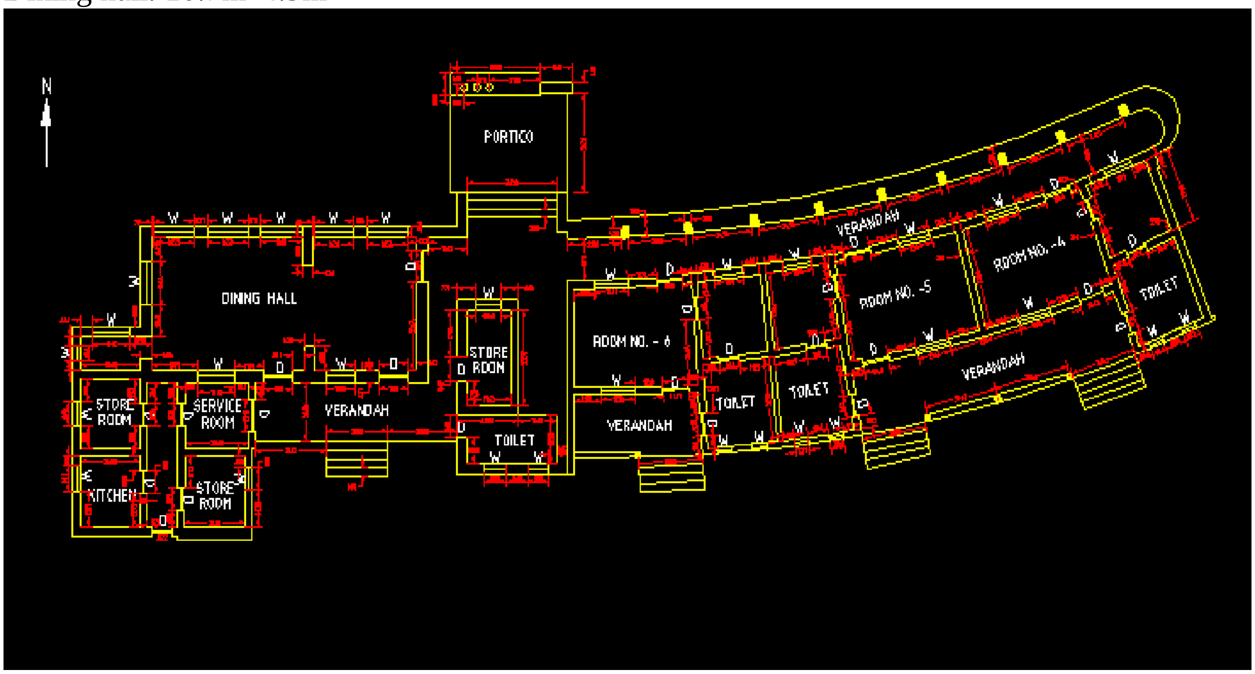



**Fig 4.1 Ground floor of the Guest House of NIT Rourkela in AUTOCAD**


**Fig 4.2 First floor of the Guest House of NIT Rourkela In AUTOCAD**

The figure below shows the implementation of the wireless scenario for the Guest House of NIT Rourkela in Qualnet[ref] Simulator. The figure is the X-Y view of the scenario in Qualnet spread over 50m*50m. The actual position of the nodes in the scenario is as follows:

## Position of Nodes:

host1 (18.75, 8.25, 2.0)
host2 (22.0, 11.0, 2.0)
host3 (29.75, 8.75, 1.5)
host4 (33.0, 11.0, 1.0)
host5 (36.0, 7.5, 1.0)
host6 (38.0, 11.25, 1.5)
host7 (3.75, 6.5,1.0)
host8 (11.25, 3.5, 1.7)
host9 (1.25, 16.25, 6.0)
host10 (18.0, 11.0, 6.5)
host11 (27.76, 13.4, 7.0)
host12 (32.02, 3.7, 6.0)
host13 (6.25, 2.75, 6.0)
host14 (24.25, 8.3, 7.0)
host15 (4.25, 12.25, 2.0)

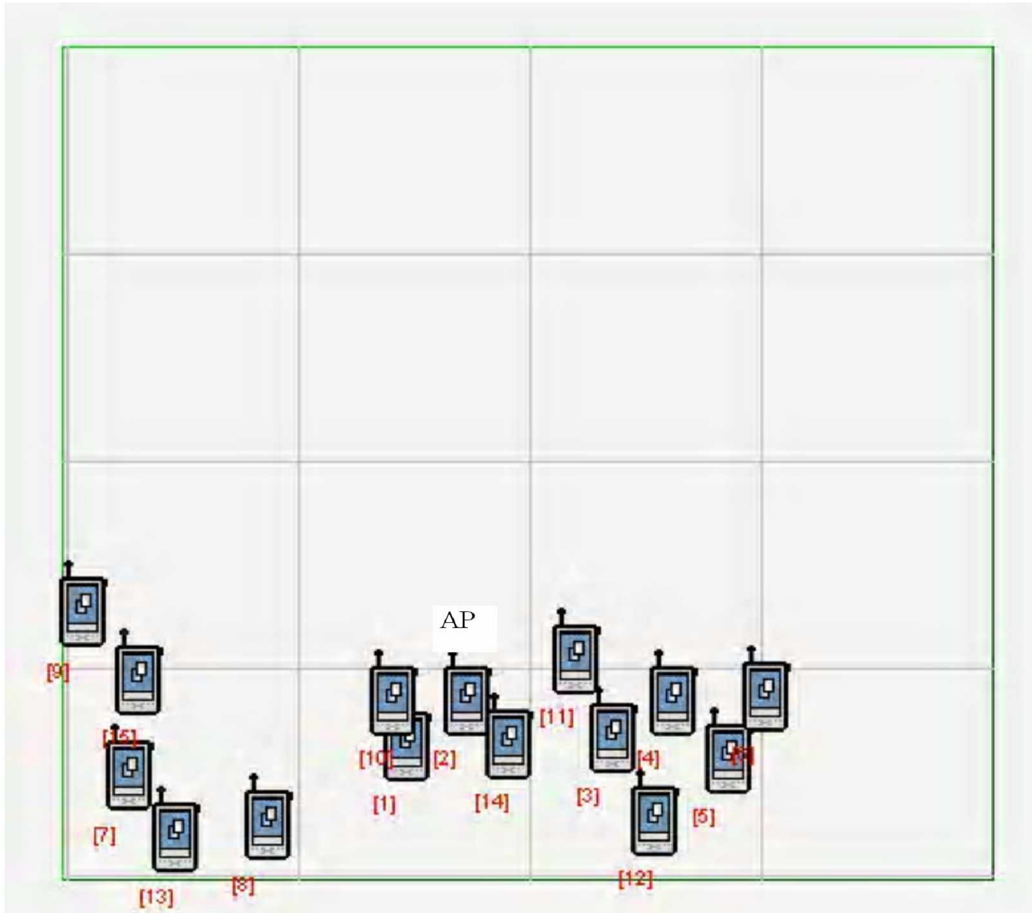



Fig 4.3 X-Y view of the Implementation of WLAN Scenario in the guest House of NIT Rourkela (50m * 50m)

# CHAPTER 5

# Comprehensive Performance Evaluation

## 5.1 Performance Evaluation Experiments

This section discusses the different scenarios that were used to measure the performance of wireless LAN[3] system under test. The scenarios are classified as: 1)Scenario with 1 AP 2)Scenario with 2 AP 3) Scenario with 3 APs 4) Scenario with 4 APs. The measurement scenarios reflect different indoor environments that are likely o be used for wireless lan scenarios. Measurements were taken by placing the different number of access points at both ground and first floor. Specific details of each of the scenarios are given in the following sections. For each scenario, the file transfer was made between the mobile nodes(client) and the access points which was made the FTP server. The file size was varied from 0.5MB to 20MB. Also the data rate for the wireless link was varied from 2Mbps to 54 Mbps. For Streaming Audio applications, APs were made the server streaming constant bit rate(CBR) data at 128 Kbps for 300s. The data rate supported by the access points for different kinds of application was measured for each of the above scenarios.

## 5.2. Scenario with 1 AP

The figure below shows the scenario created in Qualnet. The actual position of the nodes are the same as said earlier. The node no. 2 is the AP for this scenario. It has been placed in Room no. 6 in the ground floor in the Guest House of NIT Rourkela.

The AP is made the FTP server and files of different sizes are transferred from the client to the server node. File transfer of sizes 0.5MB, 1MB, 2MB, 5MB, 10MB and 20 MB was made between the clients and the server. The size of each packet was 512 bytes and the number of packets to be sent was varied according to the file size. The throughput of the server and clients for each of the file size was evaluated using Qualnet. Streaming audio application was created using Constant Bit Rate (CBR) traffic which is an inbuilt application in Qualnet and we generated a constant traffic of 128 Kbps for 300s with node 2 acting as the server.Data rate for the wireless link was varied as 2Mbps, 11 Mbps, 6Mbps, 36,Mbps and 54 Mbps. The parameters which were held constant for the whole scenario are as follows:

```
PROPAGATION-CHANNEL-FREQUENCY 2.4GHz
# Signals with powers below PROPAGATION-LIMIT (in dBm) (before the antenna gain at the receiver) are not delivered.
PROPAGATION-LIMIT -111.0
# 2-Ray Pathloss Propagation Model
PROPAGATION-PATHLOSS-MODEL TWO-RAY
PROPAGATION-SHADOWING-MODEL CONSTANT
# in dB
PROPAGATION-SHADOWING-MEAN 4.0
PROPAGATION-FADING-MODEL RAYLEIGH
PROPAGATION-FADING-MAX-VELOCITY10.0
```

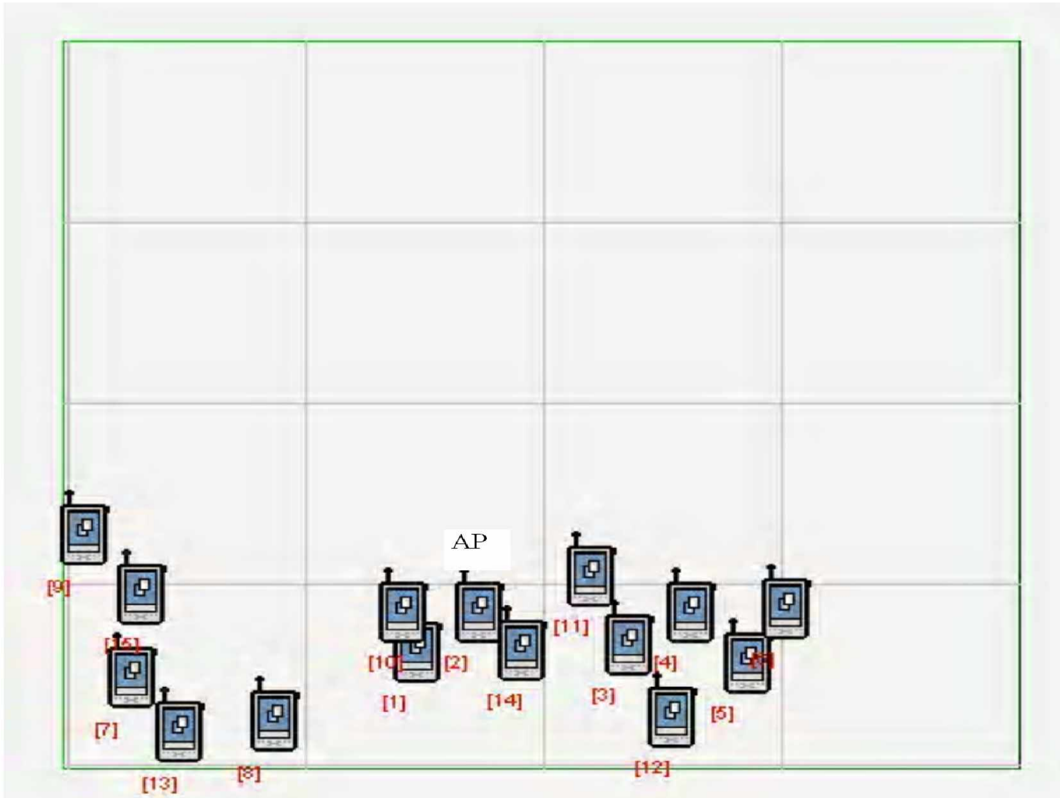



Fig.5.1 X-Y view of the Scenario with 1 AP

### 5.2.1 Simulation 1.1

The protocol used was 802.11a and the data rate was kept at 54 Mbps. FTP throughput and Streaming Audio throughput was measured at 54Mbps. We are interested particularly in the throughput of the server i.e the access point(AP). The figures below shows the client and server throughput measurements for various file sizes at 54 Mbps:

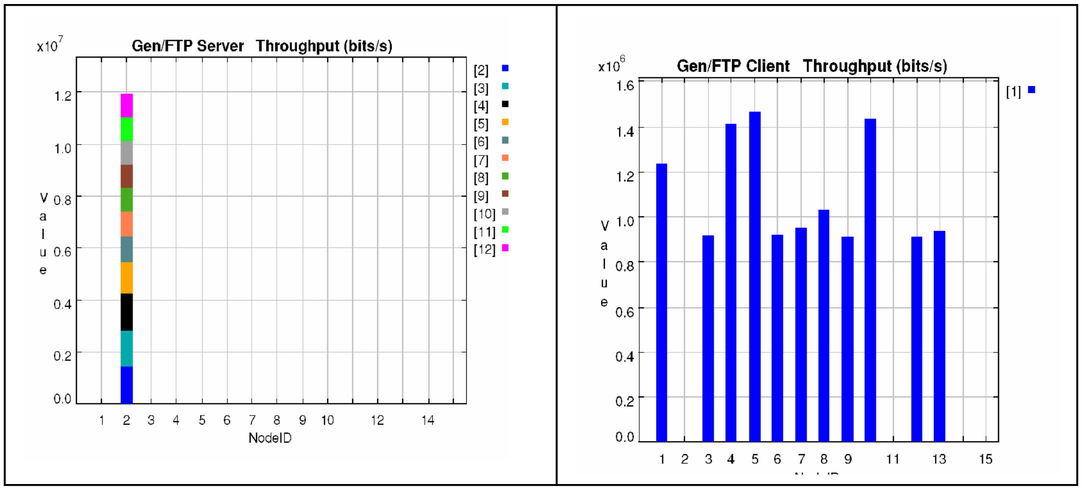
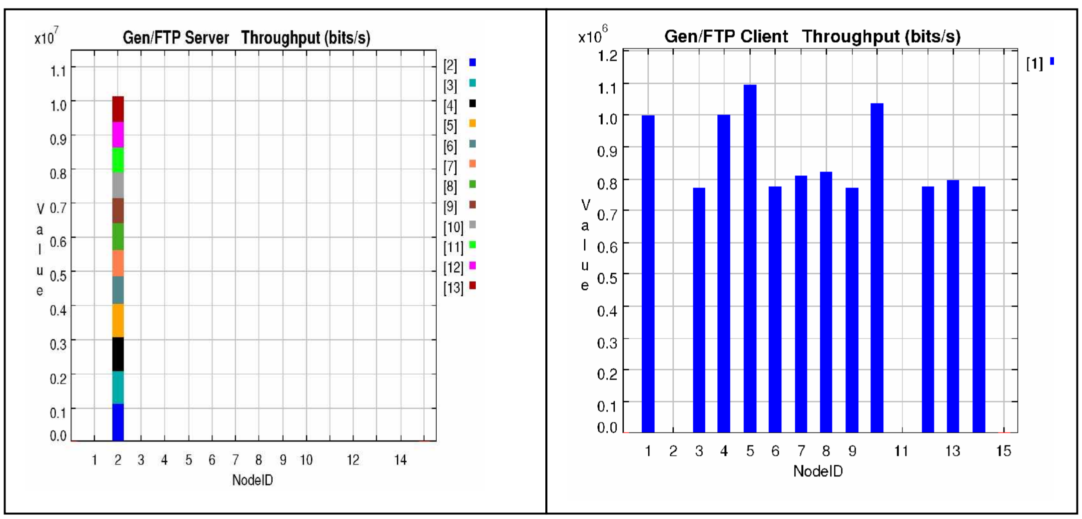



**Fig. 5.2.1.1 APs and Clients throughput for 0.5MB file**




**Fi g. 5.2.1.2 APs and Clients throughput for 1MB file**

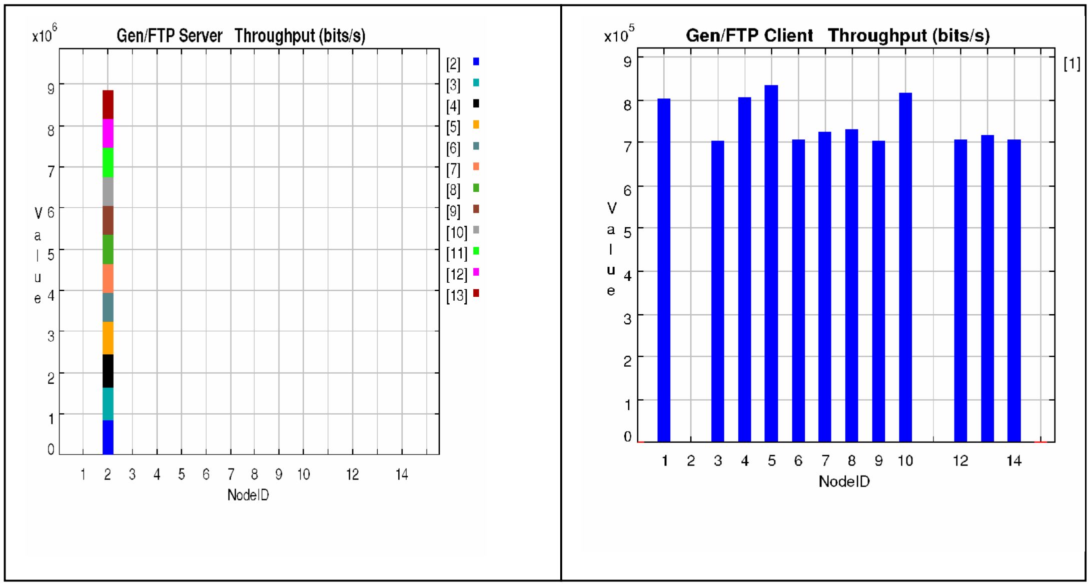



**Fig. 5.2.1.3 AP and Client throughput for 2 MB file**

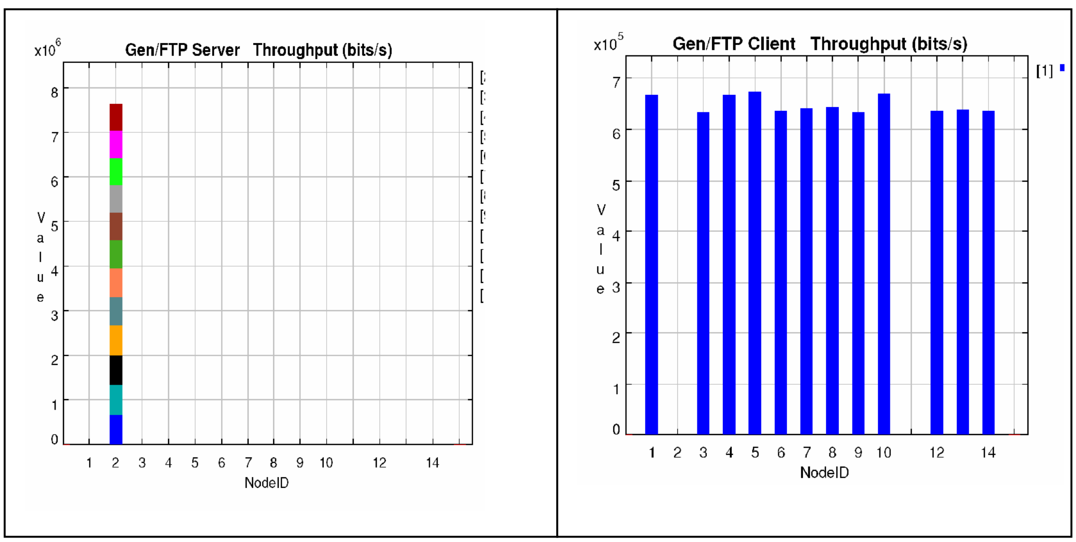



**Fig 5.2.1.4 AP & Clients throughput 5MB&10MB**

Streaming Audio

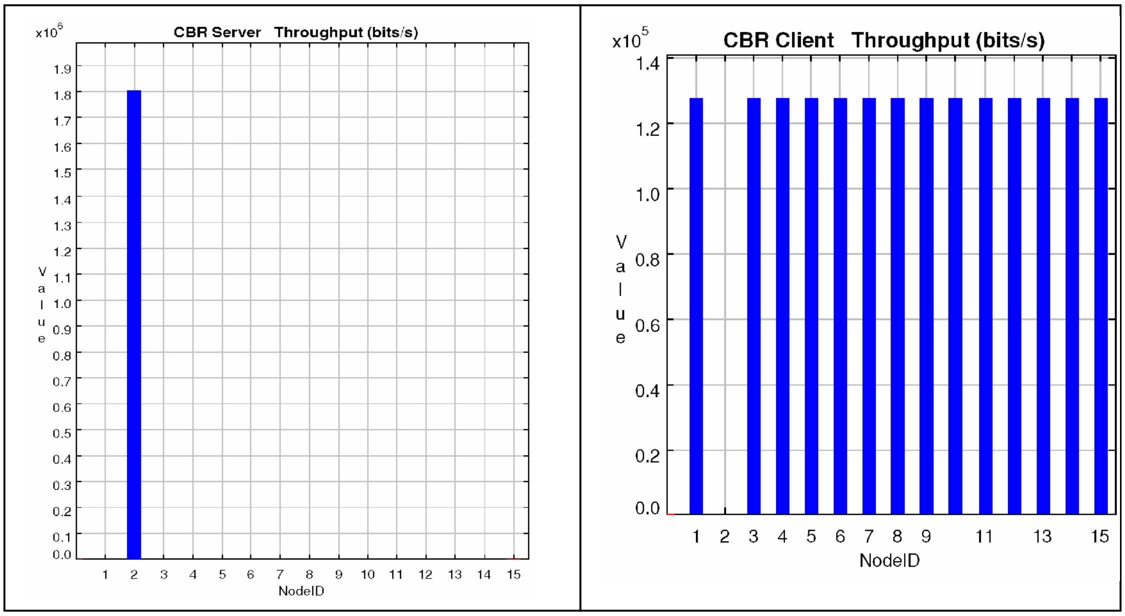



Fig.5.2.1.5 AP & Clients throughput for 128kbps CBR

## 5.2.2 Simulation 1.2

The protocol used was 802.11a and the data rate was kept at 36 Mbps. FTP throughput and Streaming Audio throughput was measured at 36Mbps.. The figures below shows the client and server throughput measurements for various file sizes at 36 Mbps:

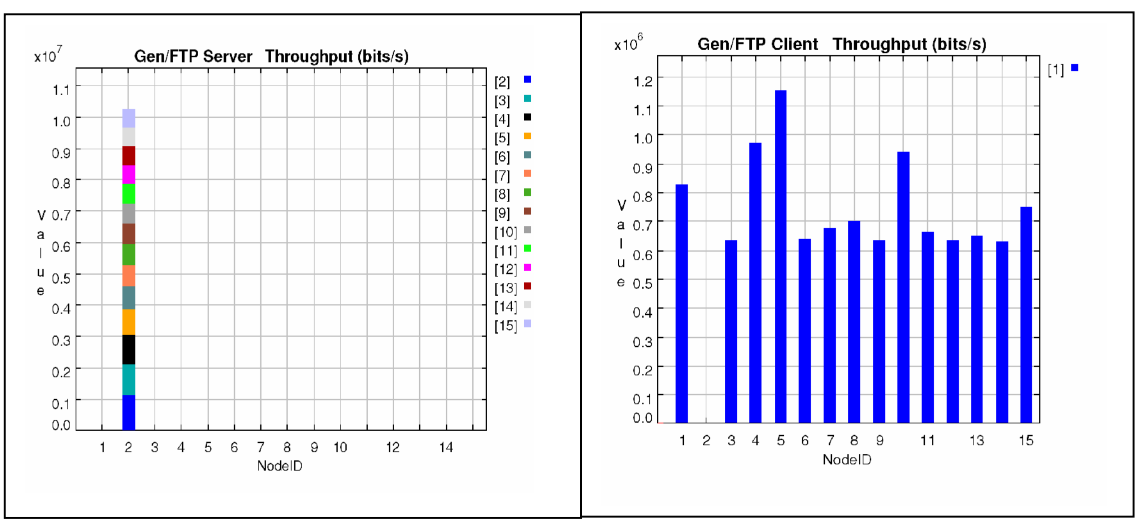



**Fig. 5.2.2.1 APs and Clients Throughput for 0.5MB file**

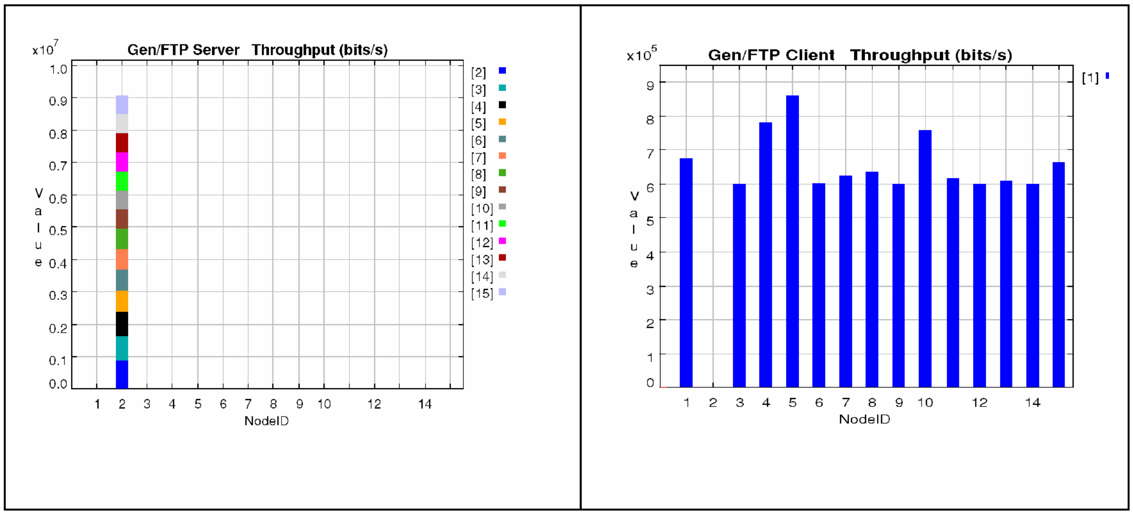



**Fig. 5.2.2.2 APs and Client Throughputs 1MB**

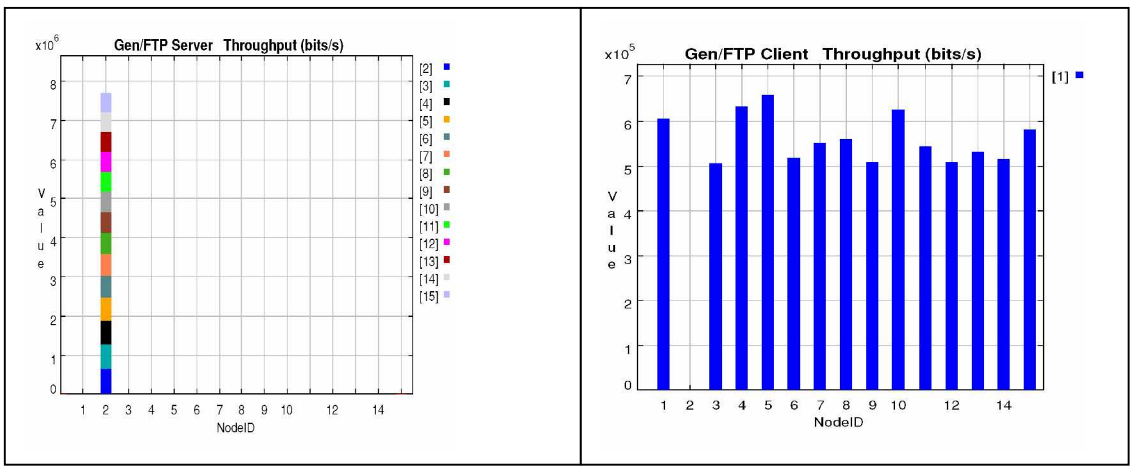



**Fig.5.2.2.3 APs and Clients Throughput for 2MB**

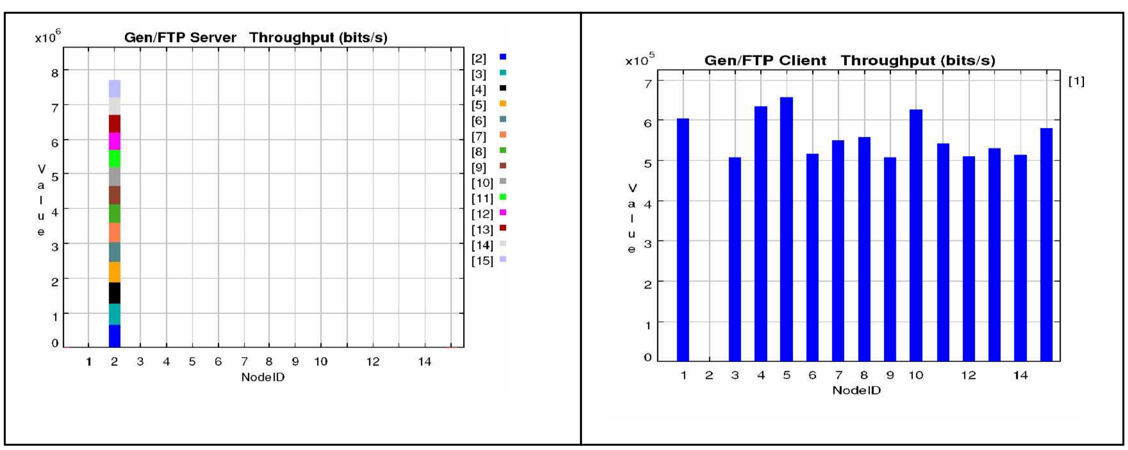



**Fig. 5.2.2.4 APs and Clients throughput 5MB,10MB files**

Streaming Audio

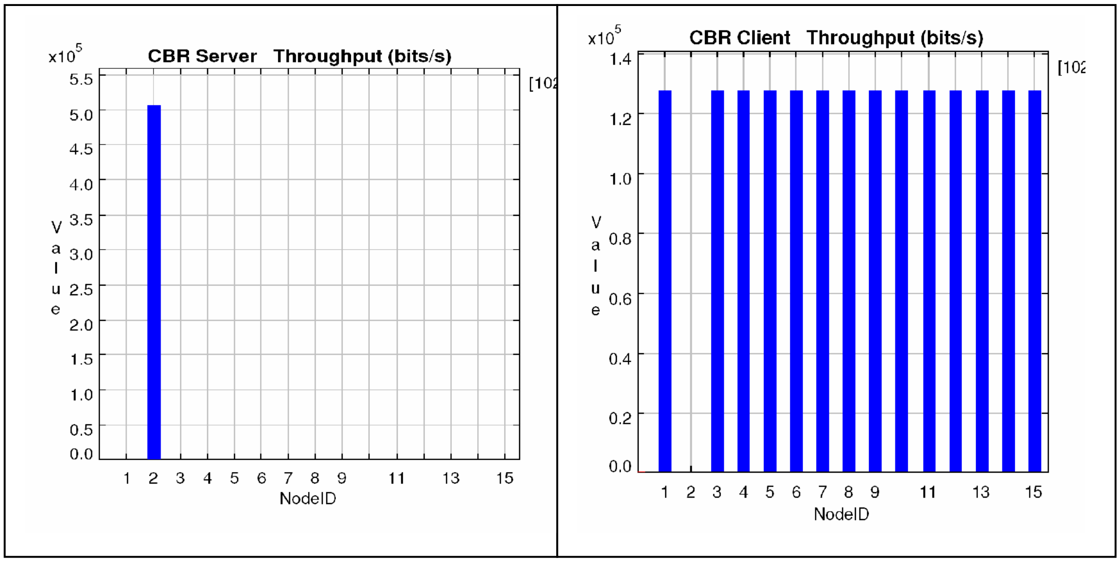



**Fig. 5.2.2.5 APs & Clients throughput 128Kbps CBR**

**Results**: From the above figures we observe that the throughput for file size of 0.5MB is around 10.2Mbps, for 1 MB file the throughput is 9 Mbps, for 2MB file the throughput is 7.8 Mbps. Similarly for file sizes of 5MB , 10 MB the throughput is found out to be 7.8 Mbps. The throughput is initially high because the file size is small and transfer takes place quickly. However with increase in file size the throughput saturates at a level which is the data rate supported using 1 AP at 36 Mbps.

### 5.2.3 Simulation 1.3

The protocol used was 802.11b and the data rate was kept at 11 Mbps. FTP throughput and Streaming Audio throughput was measured at 11Mbps.. The figures below shows the client and server throughput measurements for various file sizes at 11 Mbps:

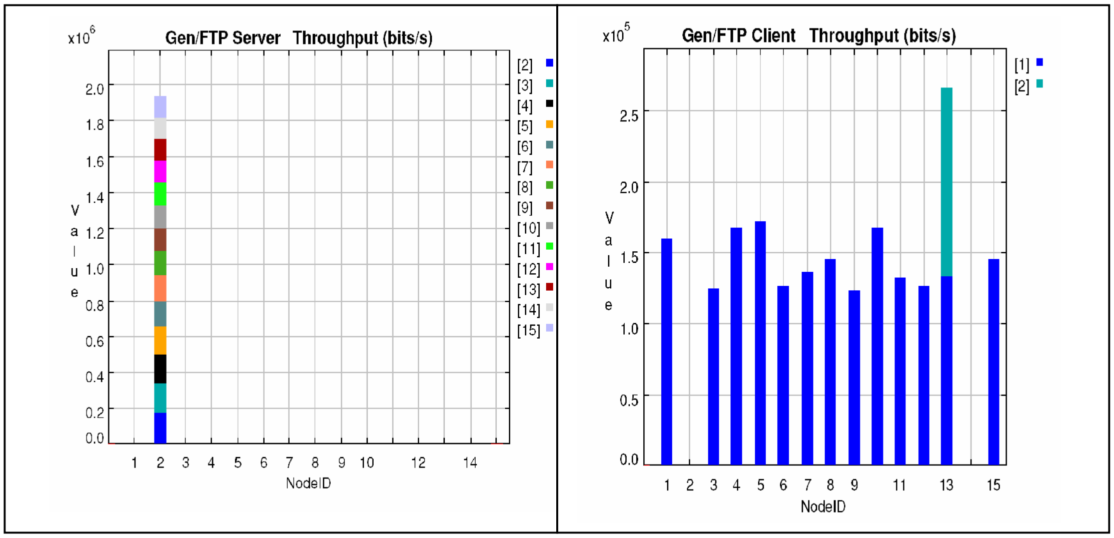



**Fig. 5.2.3.1 AP and Clients throughput 0.5MB**

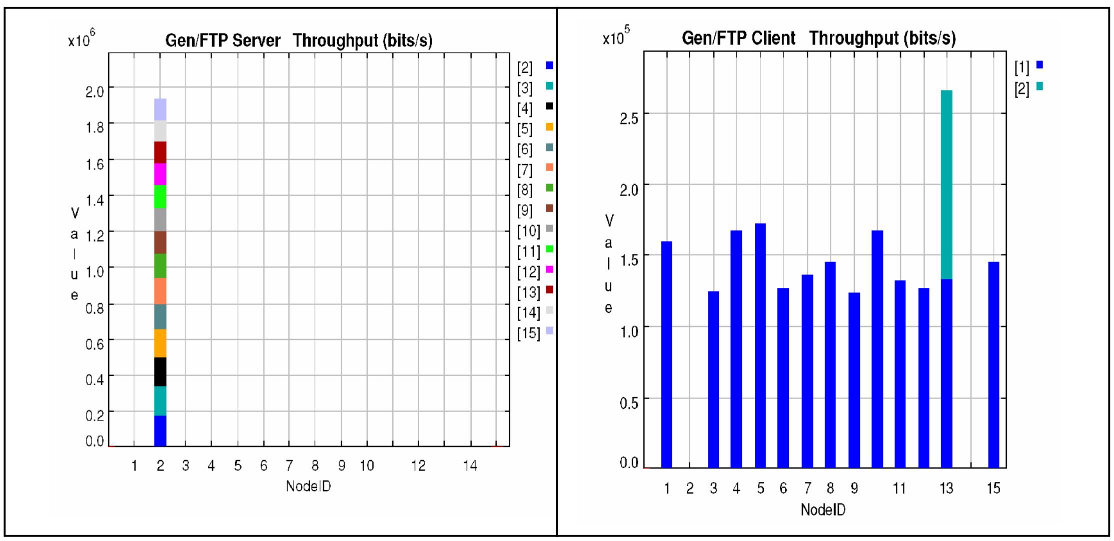



**Fig. 5.2.3.2 AP and Clients throughput 1,2,5,10 MB**

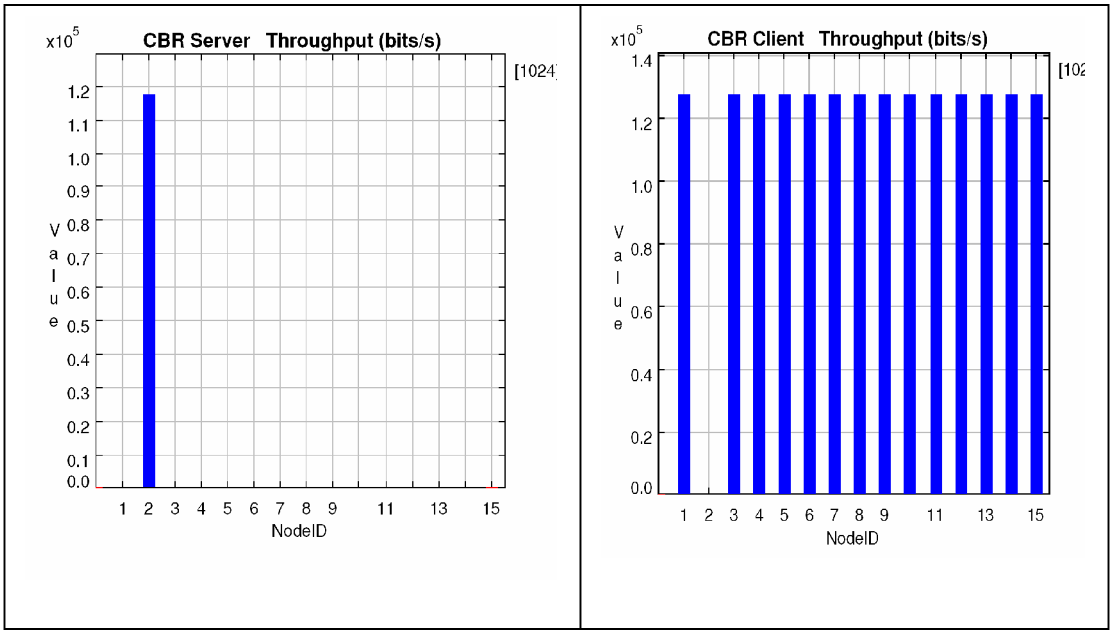



**Fig.5.2.3.3 APs and Clients throughput 128Kbps CBR**

**Results**: From the above figures we observe that the throughput of the AP for file sizes of 0.5MB, 1MB, 2MB, 5MB and 10MB is around 1.92 Mbps. The throughput in this case is constant for all file sizes taken. For smaller files less than 0.5 MB the throughput would be larger compared to 1.92 Mbps.

## 5.2.4 Simulation 1.4

The protocol used was 802.11b and the data rate was kept at 2 Mbps. File transfer of sizes 0.5MB, 1MB, 2MB, 5MB, 10MB and 20 MB was made between the clients and the server. The size of each packet was 512 bytes and the number of packets to be sent was varied according to the file size. The throughput of the server and clients for each of the file size was evaluated using Qualnet. Streaming audio application was created using Constant Bit Rate (CBR) traffic which is an inbuilt application in Qualnet and we generated a constant traffic of 128 Kbps for 300s. We are interested particularly in the throughput of the server i.e the access point(AP). The figures below shows the client and server throughput measurements for various file sizes at 2 Mbps:

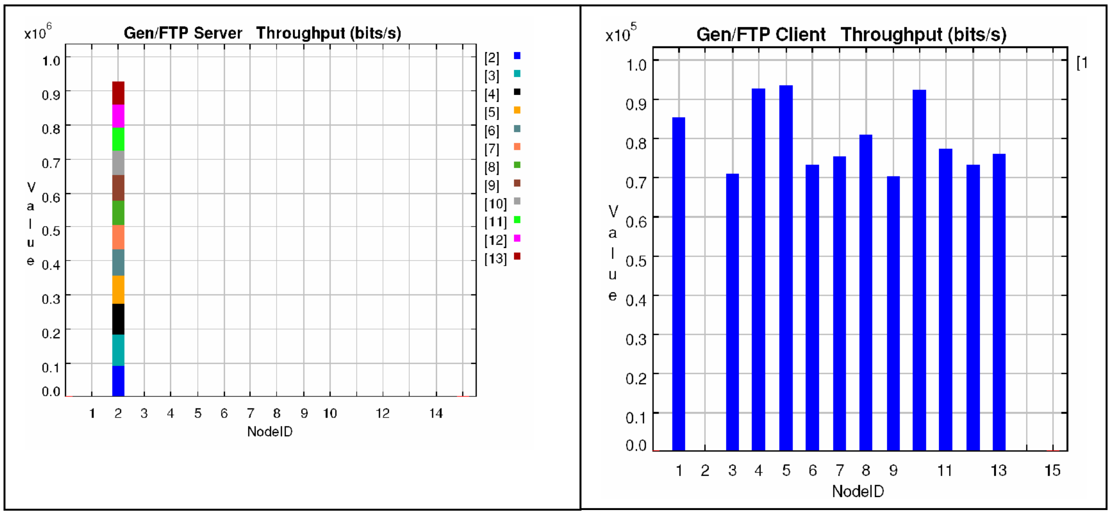



**Fig. 5.2.4.1 APs and Clients Throughput for 0.5,1, 2,5,10MB**

**Streaming Audio**

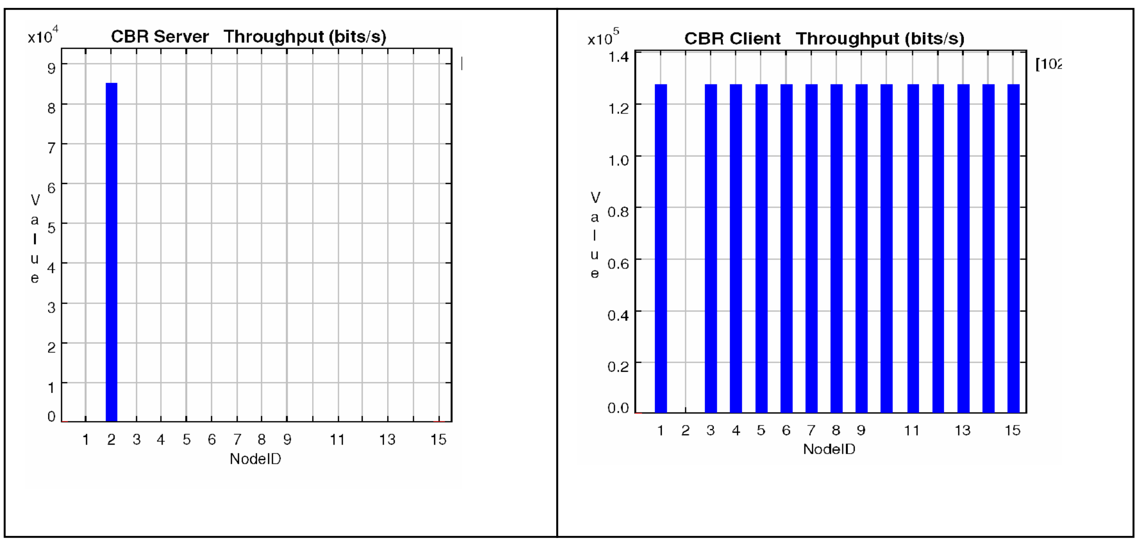



**Fig.5.2.4.2 AP and Clients throughput for 128Kbps CBR**

# 5.3 Scenario with 2 AP

The figure below shows the actual scenario created in Qualnet with 2 access points (AP). The nodes 2 and 14 are configured as APs. The node no. 2 is placed at Room No.6 in the ground floor while node no. 14 is placed at Room no. 6 in the first floor. Both the nodes act as access points and are made the server for file transfer and streaming audio applications. The throughput for each of the access points for different file sizes is obtained using Qualnet. Data rates are varied as in the above scenario. The parameters which are to be held constant over the whole scenario are the same as in the Scenario with 1 AP.

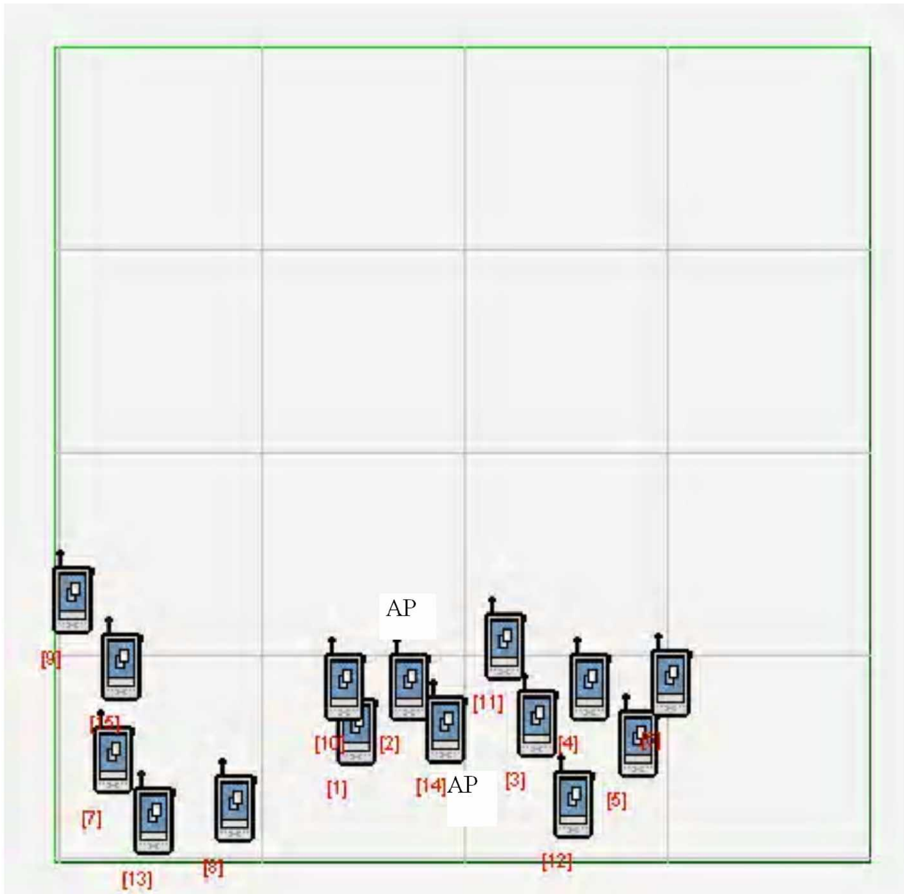



**Fig. 5.3 X-Y view of the scenario with 2 AP**

### 5.3.1 **Simulation 2.1**

The protocol used was 802.11a and the data rate was kept at 54 Mbps. FTP throughput and Streaming Audio throughput was measured at 54Mbps. We are interested particularly in the throughput of the servers i.e the access points(AP). The figures below shows the client and server throughputs measurements for various file sizes at 54 Mbps:

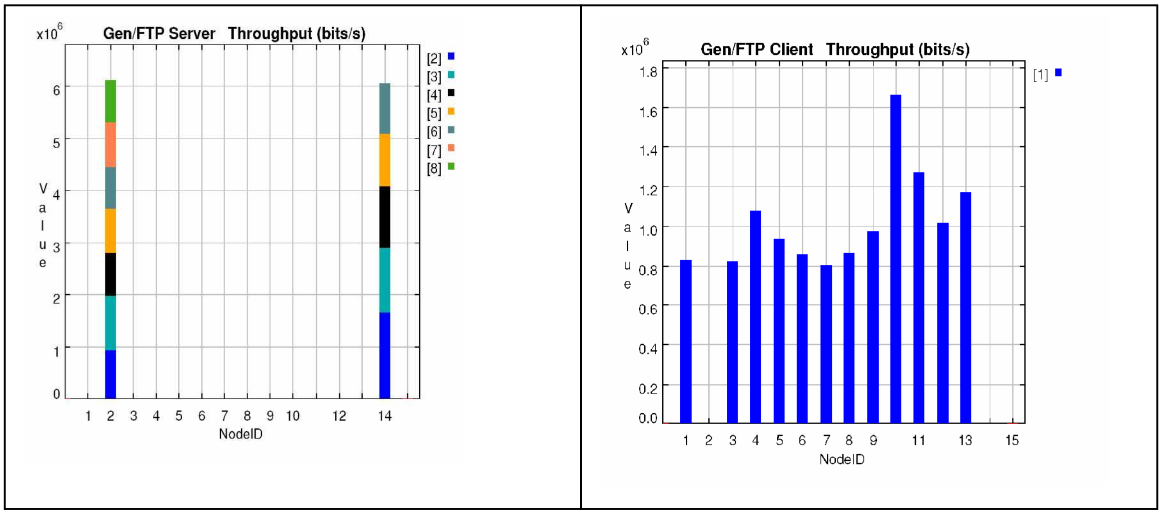



**Fig. 5.3.1.1 AP & Clients Throughput for 0.5MB file**

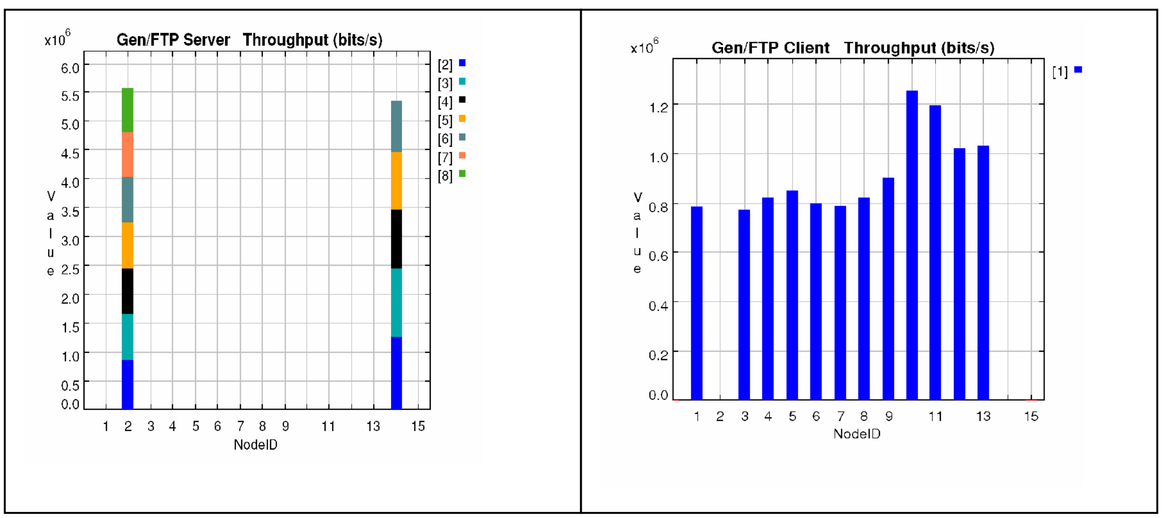



**Fig.5.3.1.2 AP & Clients throughput for 1 MB**

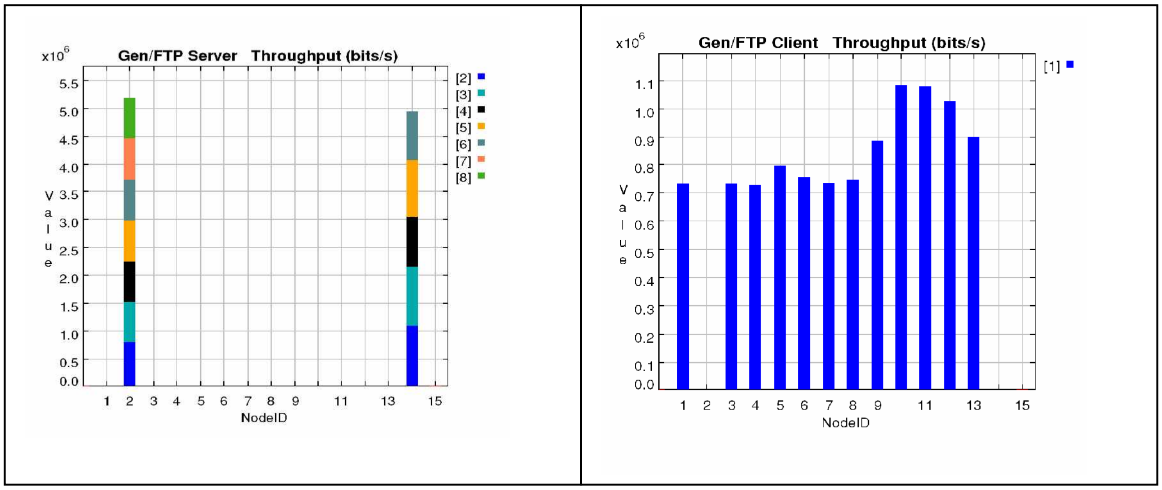



**Fig.5.3.1.3 AP & Clients throughput for 2MB file**

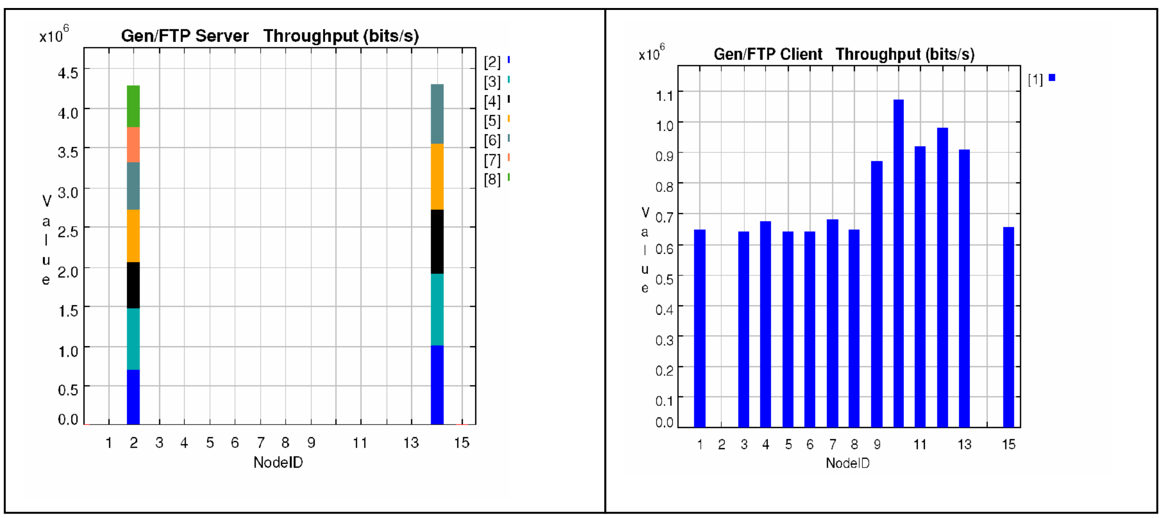



**Fig. 5.3.1.4 AP & Clients throughput for 5MB, 10MB files**

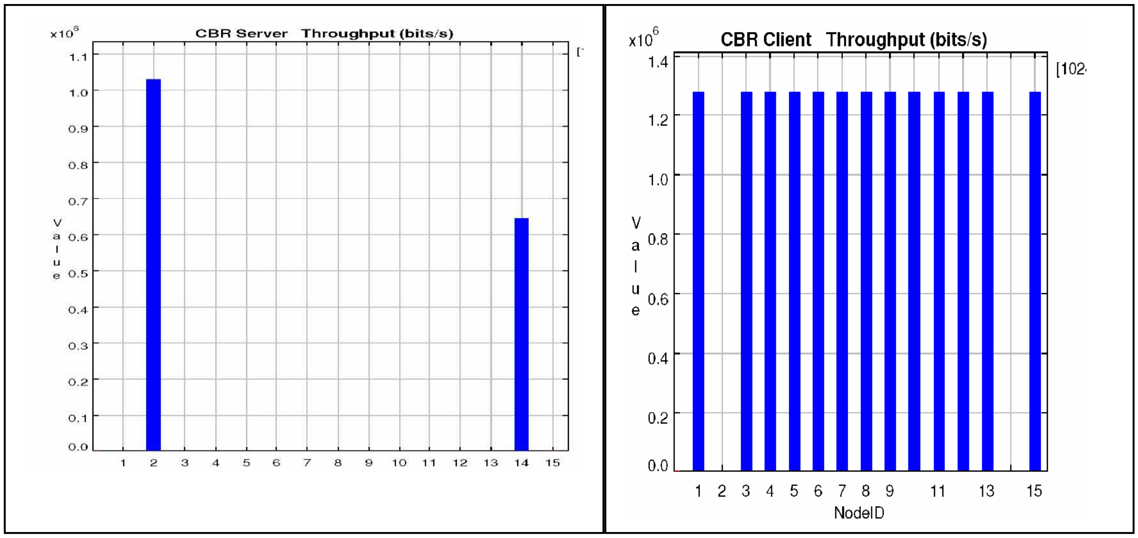



**Fig. 5.3.1.5 APs and Clients throughput for 128Kbps CBR**

**Results**: The total throughput of the APs at 54Mbps for 0.5MB file is 12.1 Mbps. As the file size increases the throughput value drops to 11Mbps for 1 MB file , 10.1 Mbps for 2 MB file and then saturates at 8.7Mbps for 5MB, 10MB and files of larger size.

## 5.3.2 Simulation 2.2

The protocol used was 802.11a and the data rate was kept at 36Mbps. FTP throughput and Streaming Audio throughput was measured at 36Mbps. We are interested particularly in the throughput of the servers i.e the access points(AP). The figures below shows the client and server throughputs measurements for various file sizes at 36 Mbps:

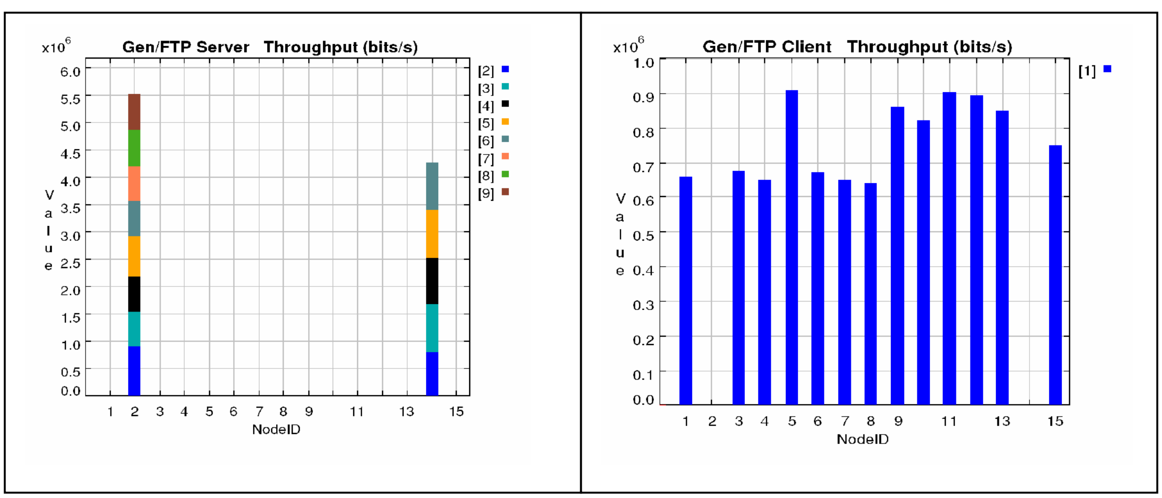



**Fig 5.3.2.1 AP & Clients throughput for 0.5MB file**

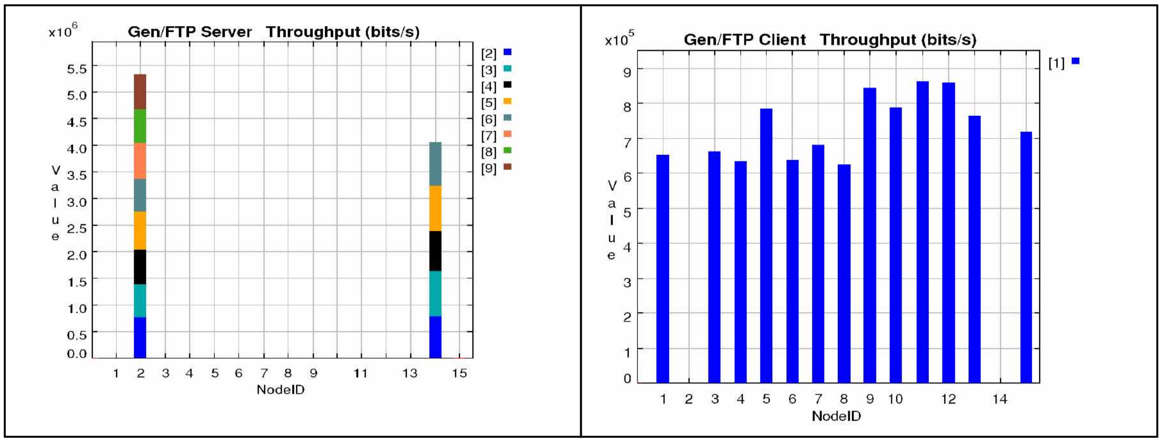



**Fig. 5.3.2.2 AP & Clients throughput for 1MB file**

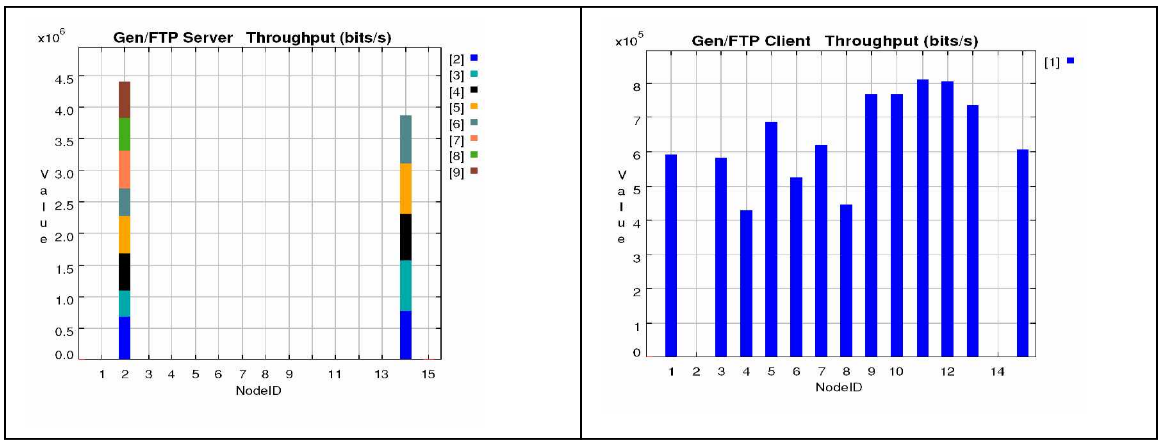



**Fig 5.3.2.3 AP & Clients throughput for 2MB file**

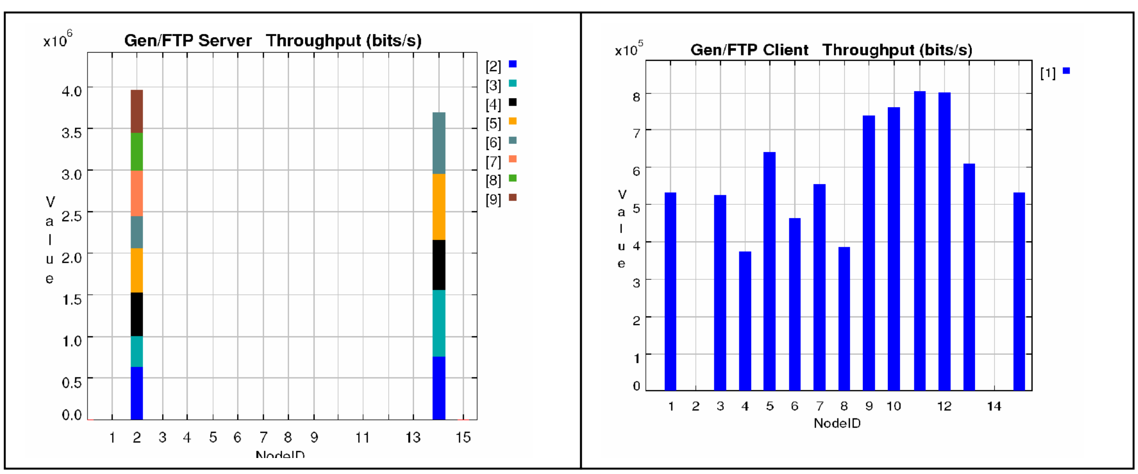



**Fig. 5.3.2.4 AP & Clients throughput for 5MB, 10MB file**

## Streaming Audio

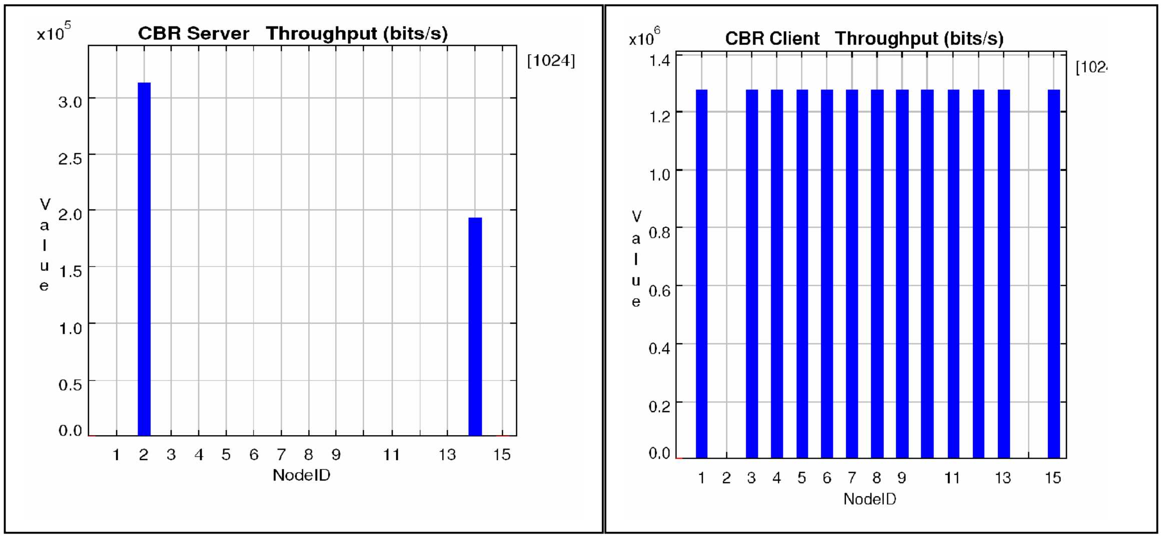



**Fig. 5.3.2.5 APs and Clients throughput for 128Kbps CBR**

**Results**: The throughput variation for the access points with variation in file size at 36 Mbps data rate is shown. The total throughput for 0.5MB file is 9.8Mbps, while for 1MB file the throughput is 9.4Mbps. The throughput value when 2 MB file is transferred is obtained as 8.3Mbps. The minimum data rate supported by the access points is around 7.7 Mbps the throughput values for 5MB and files of larger sizes.

## 5.3.3 Simulation 2.3

The protocol used was 802.11b and the data rate was kept at 11Mbps. FTP throughput and Streaming Audio throughput was measured at 11Mbps. We are interested particularly in the throughput of the servers i.e the access points(AP). The figures below shows the client and server throughputs measurements for various file sizes at 11Mbps:

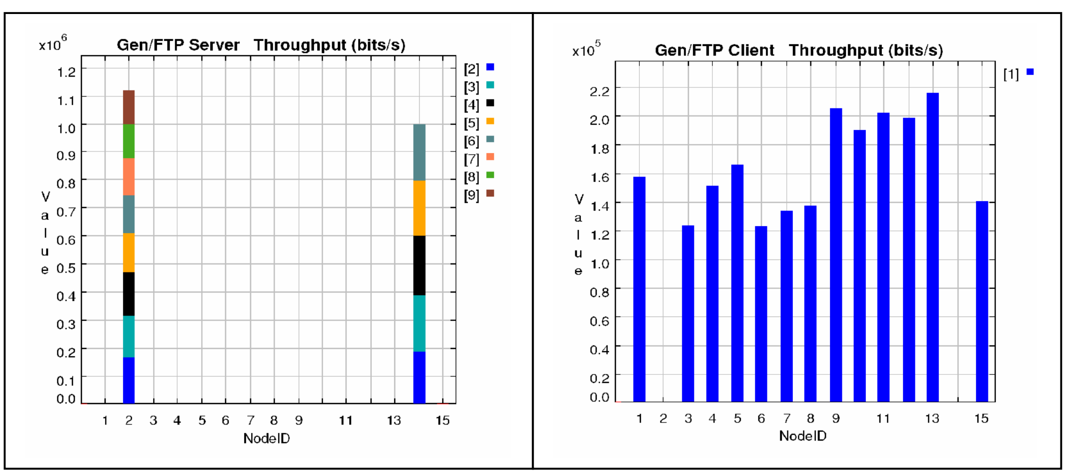



**Fig. 5.3.3.1 AP & Clients throughput for 0.5MB**

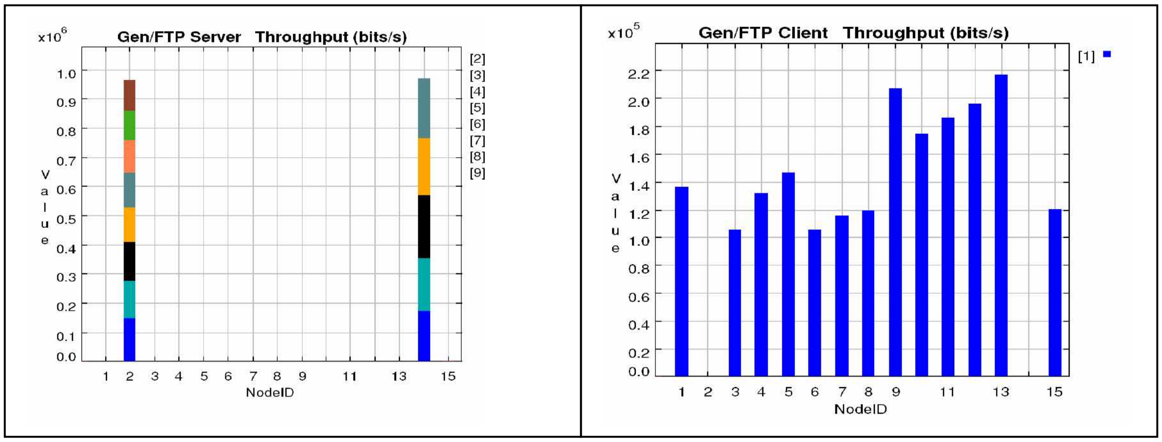


**Fig 5.3.3.2 AP & Clients throughput for 1MB, 2MB & larger files**

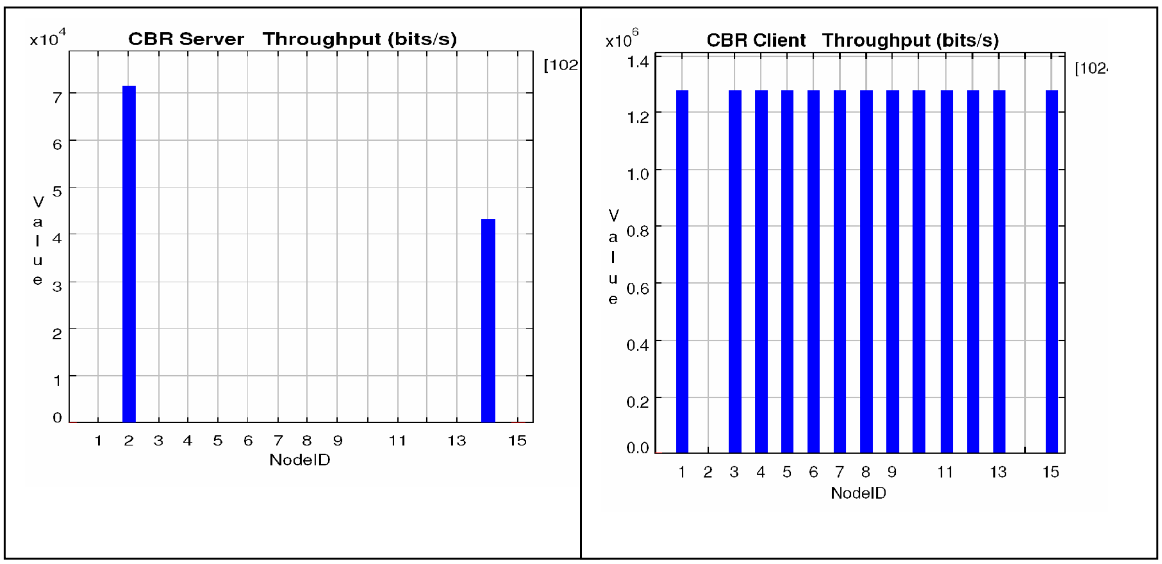


**Fig. 5.3.3.3APs and Clients throughput for 128Kbps CBR @ 11Mbps**

**Results**: The throughput results for varying file sizes at 11 Mbps data rate are as shown above. The total throughput of the access points for 0.5MB file is found to be around 2.1 Mbps. Files of larger sizes 1MB, 2MB and higher the throughput value is found out to be 1.96 Mbps.

## 5.3.4 Simulation 2.4

The protocol used was 802.11b and the data rate was kept at 2 Mbps. FTP throughput and Streaming Audio throughput was measured at 2 Mbps. We are interested particularly in the throughput of the servers i.e the access points(AP). The figures below shows the client and server throughputs measurements for various file sizes at 2Mbps:

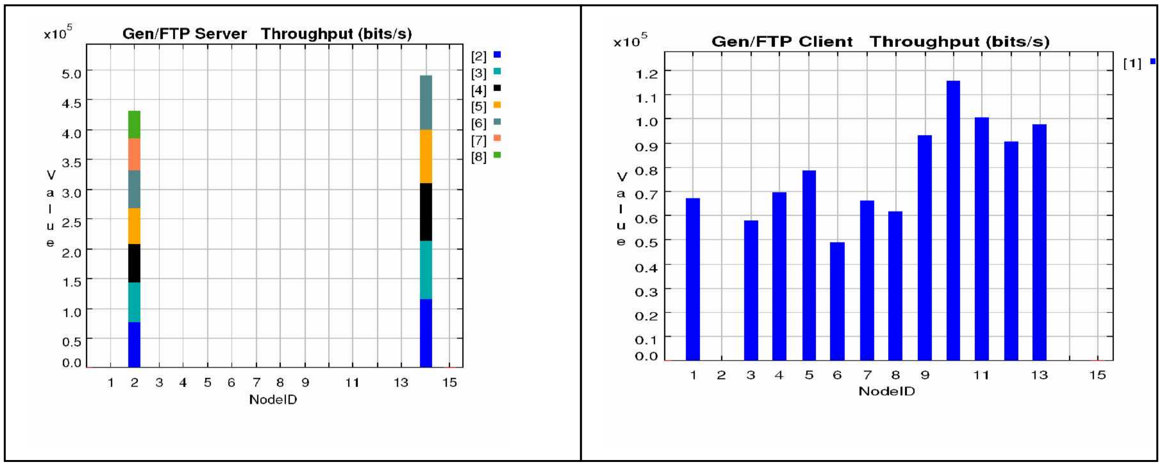



**Fig. 5.3.4.1.APs & Clients throughput for 0.5MB, 1MB and larger files**

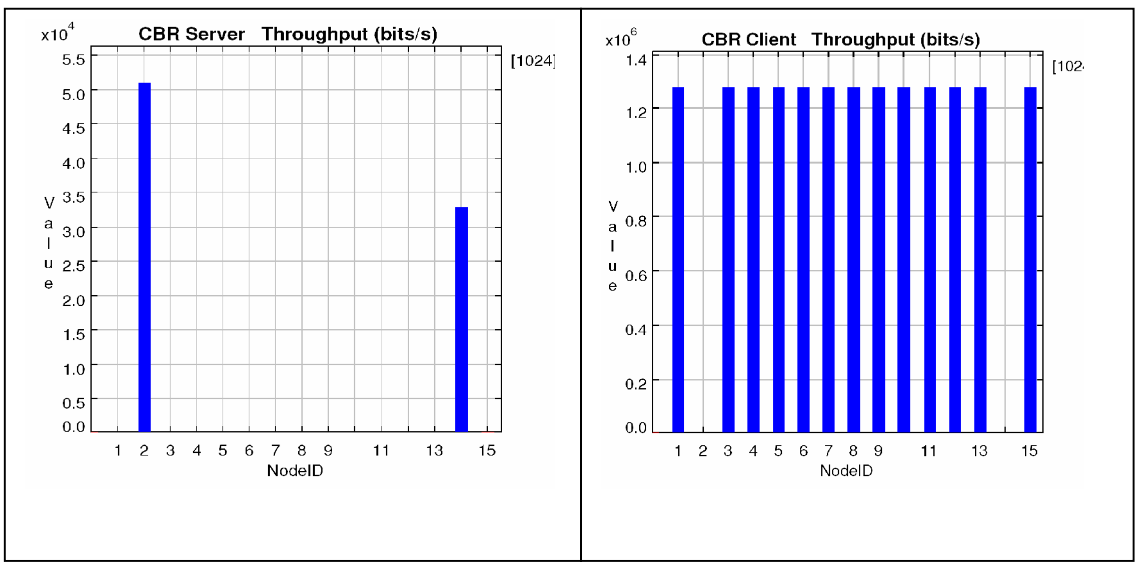



**Fig. 5.3.4.2 APs and Clients throughput for 128Kbps CBR @2Mbps**

**Results**: The total throughput of the access points using 2 Mbps wireless link is found to be 0.92Mbps for the file sizes considered in our simulations. This is the data rate which can be supported by the access points. For smaller files the throughput will be higher.

## 5.4 Scenario with 3 AP

The figure below shows the actual scenario created in Qualnet with 3 access points (AP). The nodes 2 ,9and 14 are configured as APs. The node no. 2 is placed at Room No.6 in the ground floor, node no. 14 is placed at Room no. 6 in the first floor and node no.9 is placed in the Dining Hall. All the three nodes act as access points and are made the server for file transfer and streaming audio applications. The throughput for each of the access points for different file sizes is obtained using Qualnet. Data rates are varied as in the above scenario. The parameters which are to be held constant over the whole scenario are the same as in the Scenario with 1 AP.

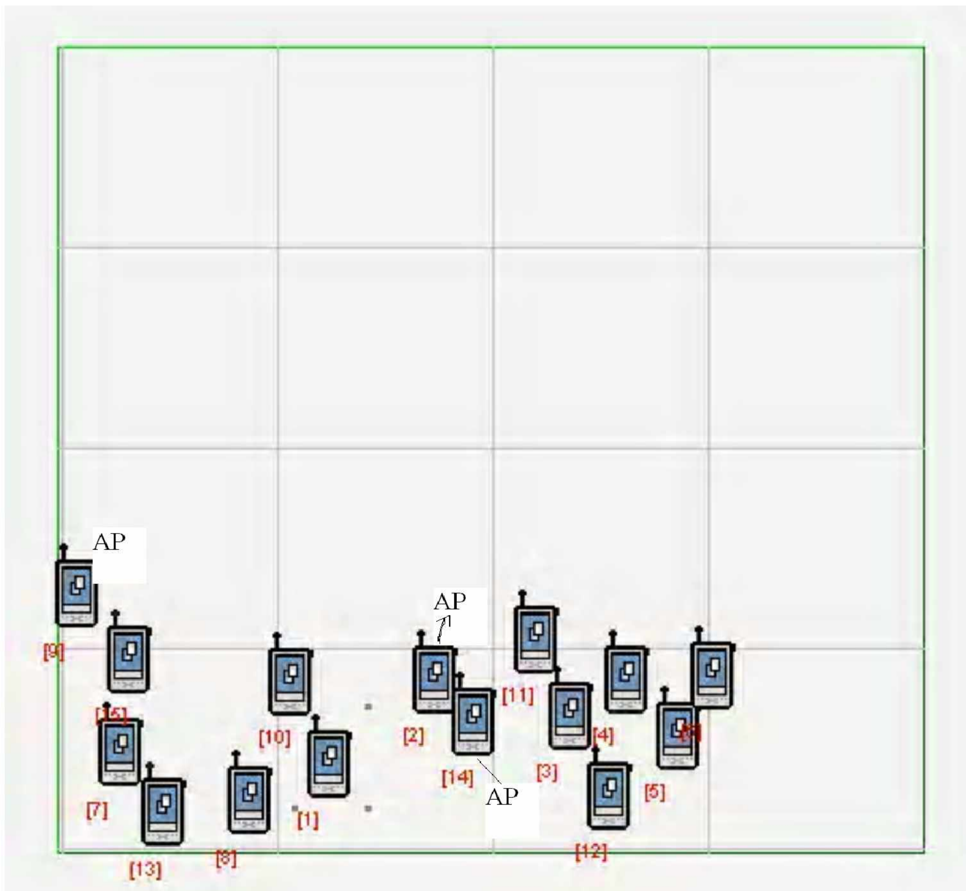



**Fig. 5.4 X-Y view of the Scenario with 3 AP**

### 5.4.1 Simulation 3.1

The protocol used was 802.11a and the data rate was kept at 54Mbps.FTP throughput and Streaming Audio throughput was measured at 54Mbps. We are interested particularly in the throughput of the servers i.e the access points(AP). The figures below shows the client and server throughputs measurements for various file sizes at 54 Mbps:

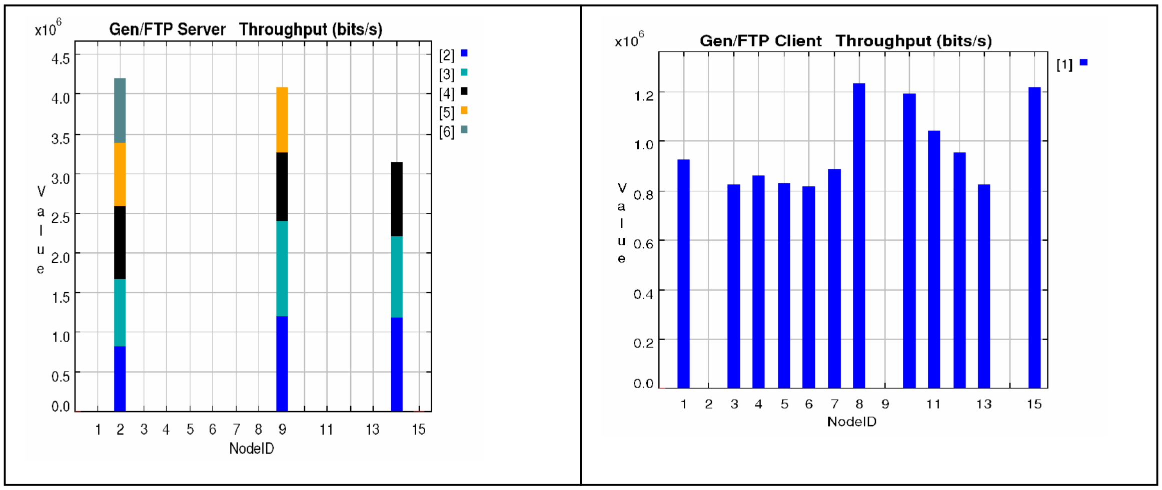



**Fig. 5.4.1.1APs & Clients throughput for 0.5 MB file**

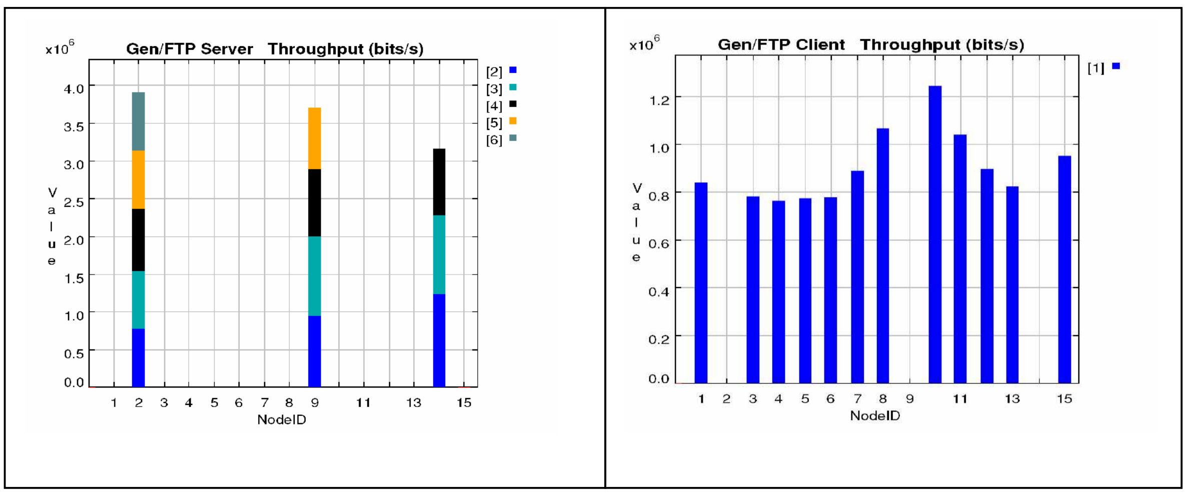



**Fig 5.4.1.2 APs & Clients throughput for 1MB file**

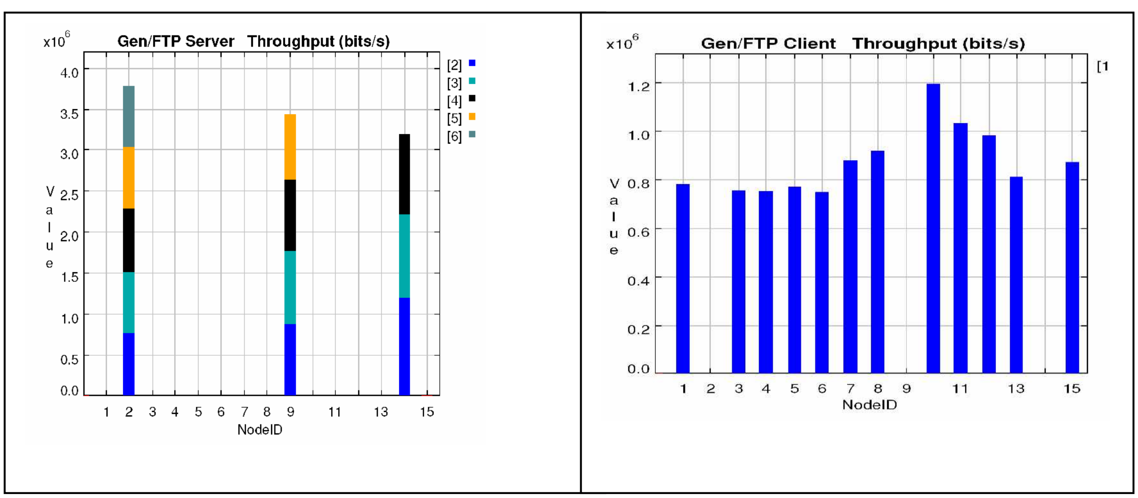



**Fig 5.4.1.3 APs and Clients throughput for 2MB file**

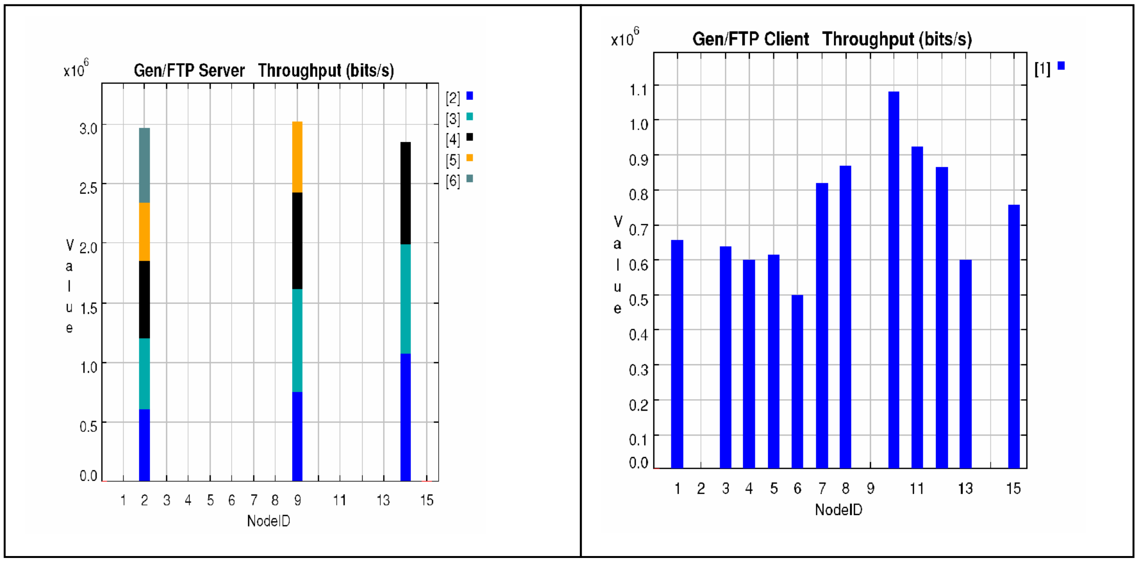



**Fig. 5.4.1.4 APs and Clients throughput for 5MB, 10MB files**

**Results**: The figure above shows the throughput values of the FTP servers for different file sizes. The total throughput for transfer of a file size of 0.5MB is found out to be 11.4Mbps. When the file size is increased to 1MB the throughput value decreases to 10.8Mbps. For 2 MB file the throughput value is 10.4Mbps. The minimum data rate supported by the access points is around 8.8Mbps the throughput values of 5MB, 10 MB and larger size file transfers.

## 5.4.2 Simulation 3.2

The protocol used was 802.11a and the data rate was kept at 36Mbps.FTP throughput and Streaming Audio throughput was measured at 36Mbps. We are interested particularly in the throughput of the servers i.e the access points(AP). The figures below shows the client and server throughputs measurements for various file sizes at 36 Mbps:

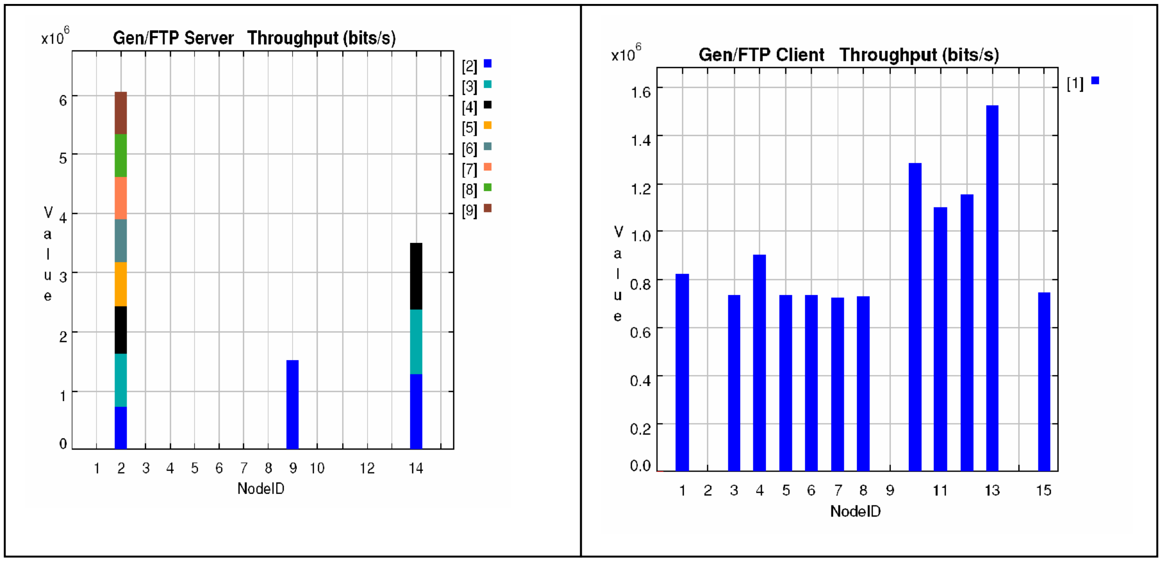



**Fig. 5.4.2.1AP & Client throughput for 0.5MB file**

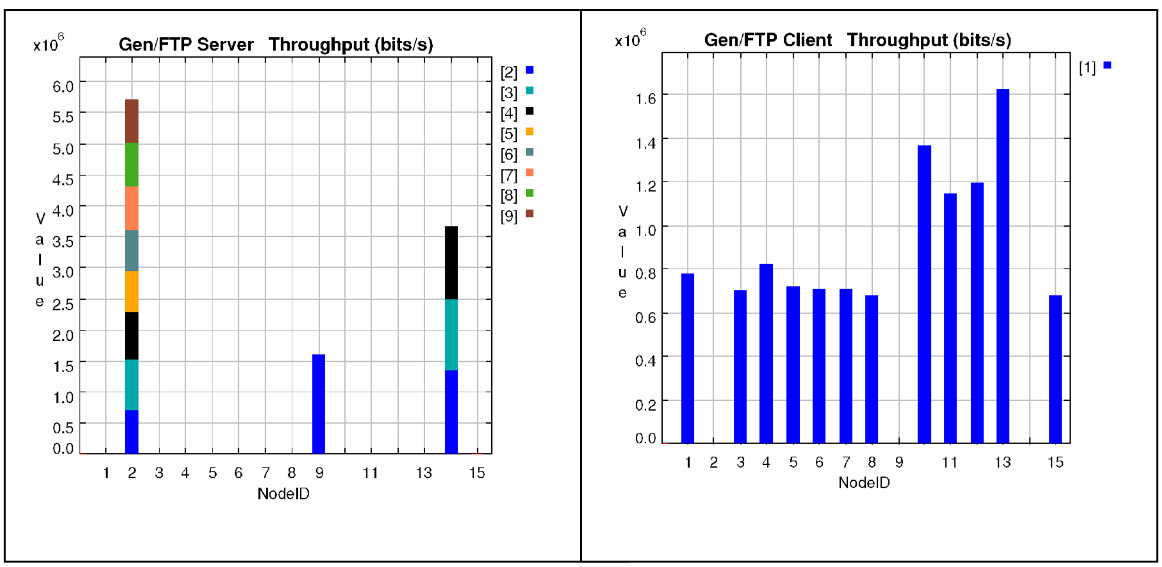



**Fig. 5.4.2.2 AP & Client throughput for 1MB file**

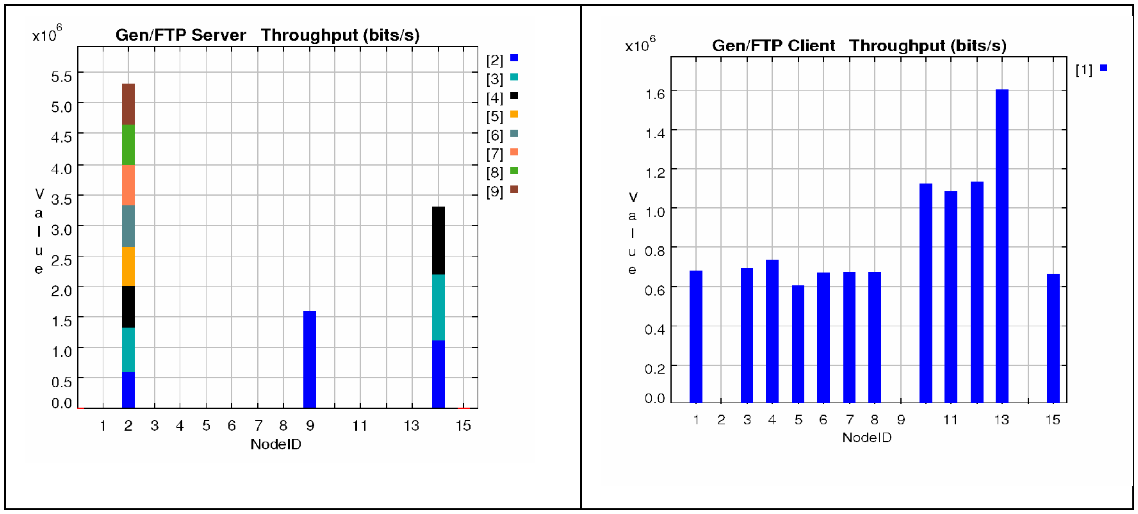



**Fig. 5.4.2.3 AP & Clients throughput for 2 MB file**

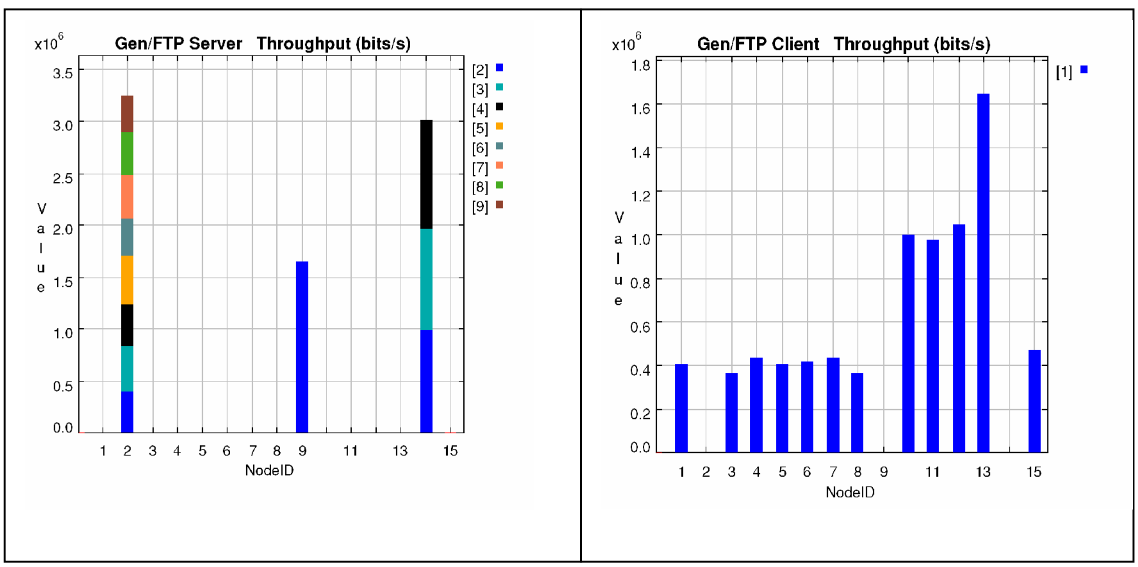



**Fig. 5.4.2.4 AP & Clients throughput for 5MB, 10MB files**

**Results**: The figure above shows the actual results FTP throughput obtained in Qualnet using 3 access points as the FTP servers. The total throughput value for transferring a file of 0.5MB is 11.0 Mbps. The throughput values for file size of 1MB is 10.8Mbps, for a file of 2 MB is 10.2 Mbps and for larger files the throughput value is found out to be7.9 Mbps which is the data rate that can be supported by the APs

### 5.4.3 Simulation 3.3

The protocol used was 802.11b and the data rate was kept at 11Mbps.FTP throughput and Streaming Audio throughput was measured at 11Mbps. We are interested particularly in the throughput of the servers i.e the access points(AP). The figures below shows the client and server throughputs measurements for various file sizes at 11 Mbps:

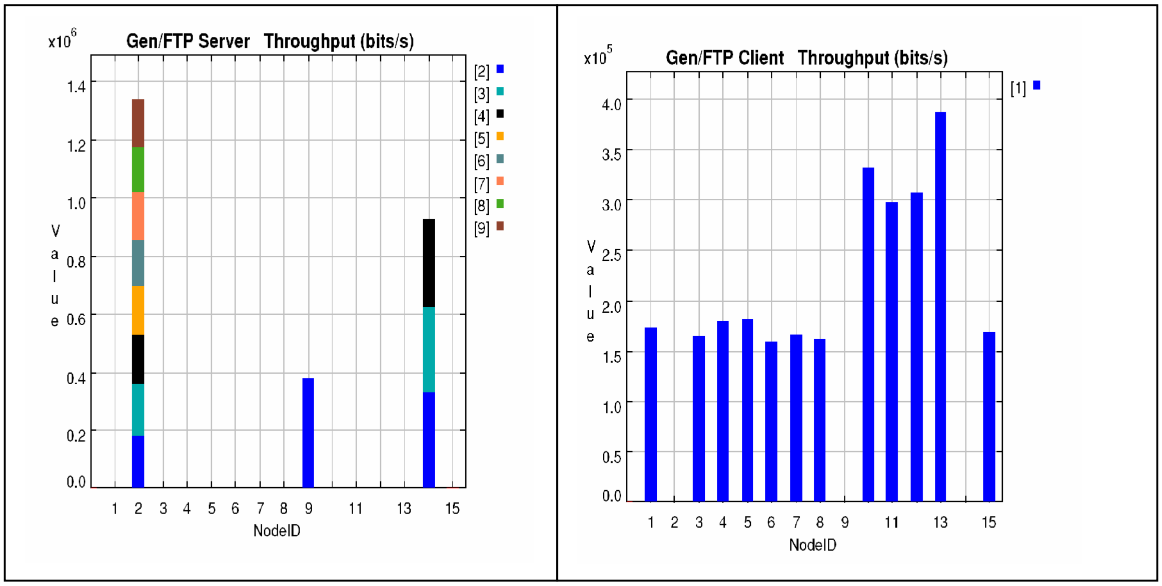



**Fig. 5.4.3.1 AP & Client throughput for 0.5MB file**

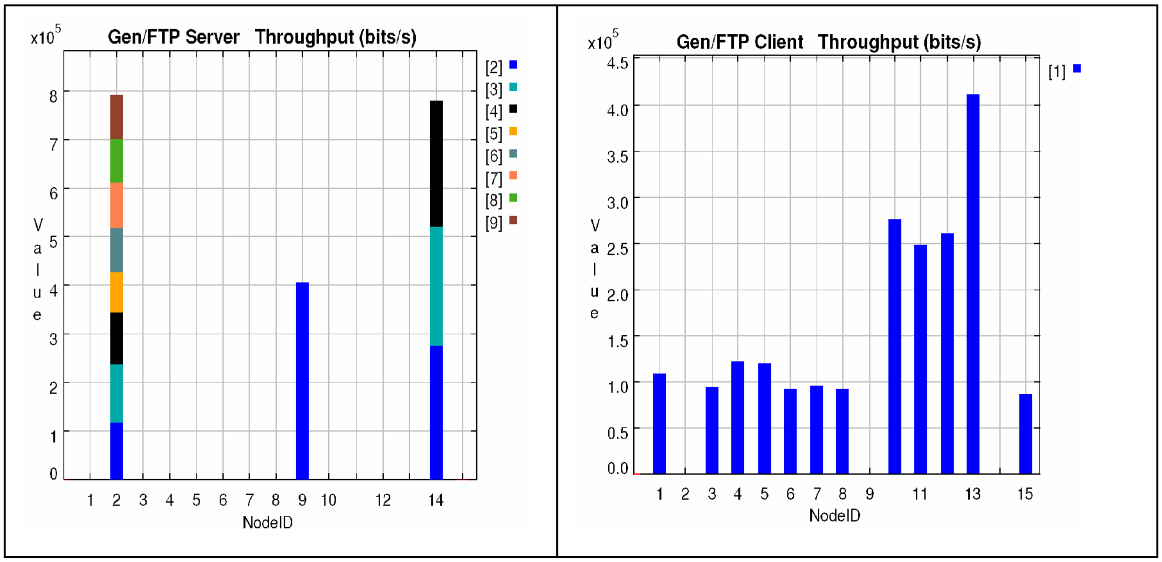



**Fig. 5.4.3.2 AP & Client throughput for 1MB file**

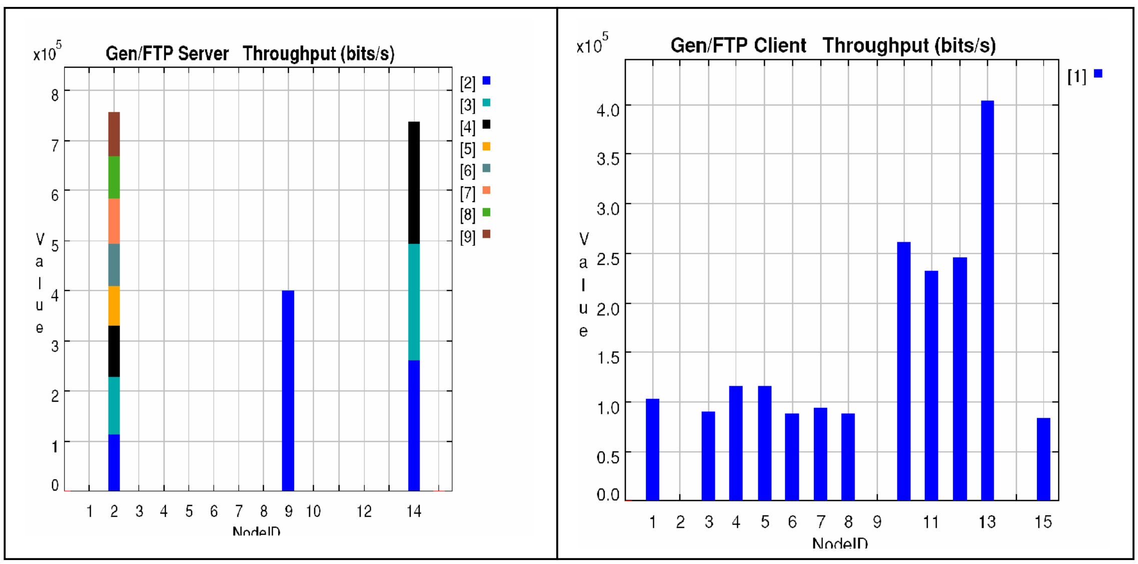



**Fig. 5.4.3.3 APs & Clients throughput for 2MB and larger files**

**Results**: The figures above shows the throughput of the clients and the servers at 11Mbps wireless link. The total throughput of the AP(server) is found out to be 2.7 Mbps when a file of 0.5MB is being transferred. The total throughput of the server for a file of 1 MB is found out to be 1.98Mbps and for files of size 2MB and larger the throughput has been observed as 1.88Mbps.

## 5.4.4 Simulation 3.4

The protocol used was 802.11b and the data rate was kept at 2 Mbps. FTP throughput and Streaming Audio throughput was measured at 2 Mbps. We are interested particularly in the throughput of the servers i.e the access points(AP).

The figures below shows the client and server throughputs measurements for various file sizes at 2 Mbps:

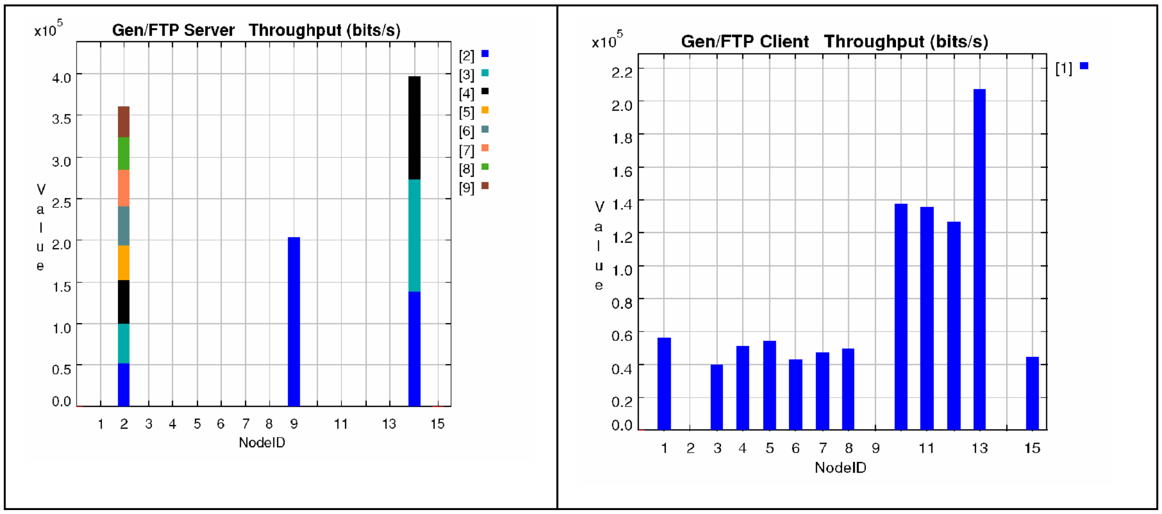



**Fig. 5.4.4.1 AP & Client throughput for 0.5MB file**

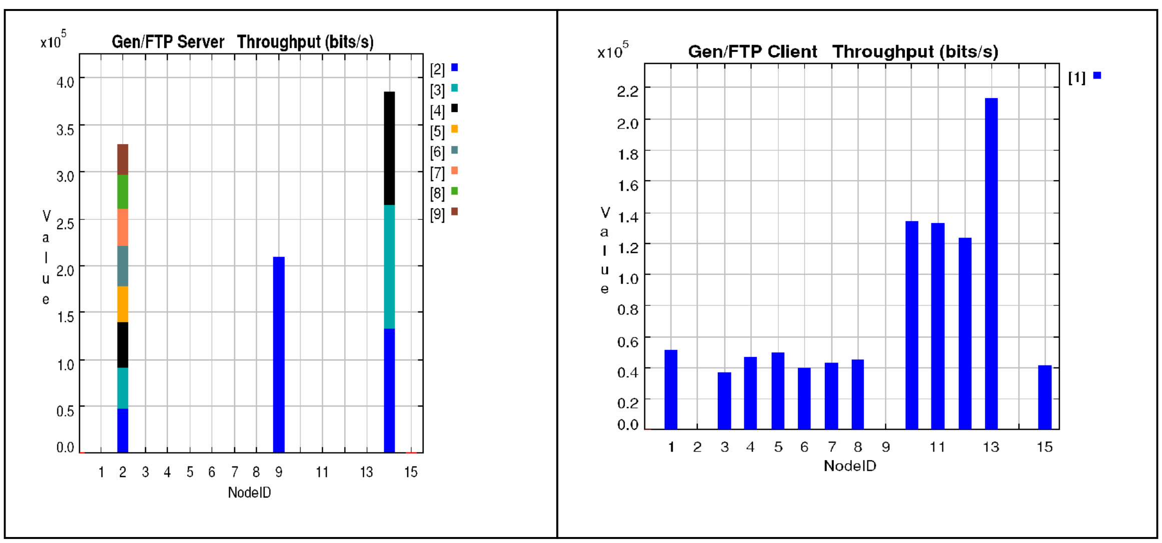



**Fig. 5.4.4.2 AP& Client throughput for 1MB, 2MB and larger files**

**Results:** The figures above shows the client server throughput for file transfer of various sizes at 2 Mbps wireless link. The total throughput obtained for a file size of 0.5 MB is observed as 0.96Mbps while for file sizes of 1MB, 2MB and files larger than 2MB is found to be 0.92Mbps.

## Streaming Audio

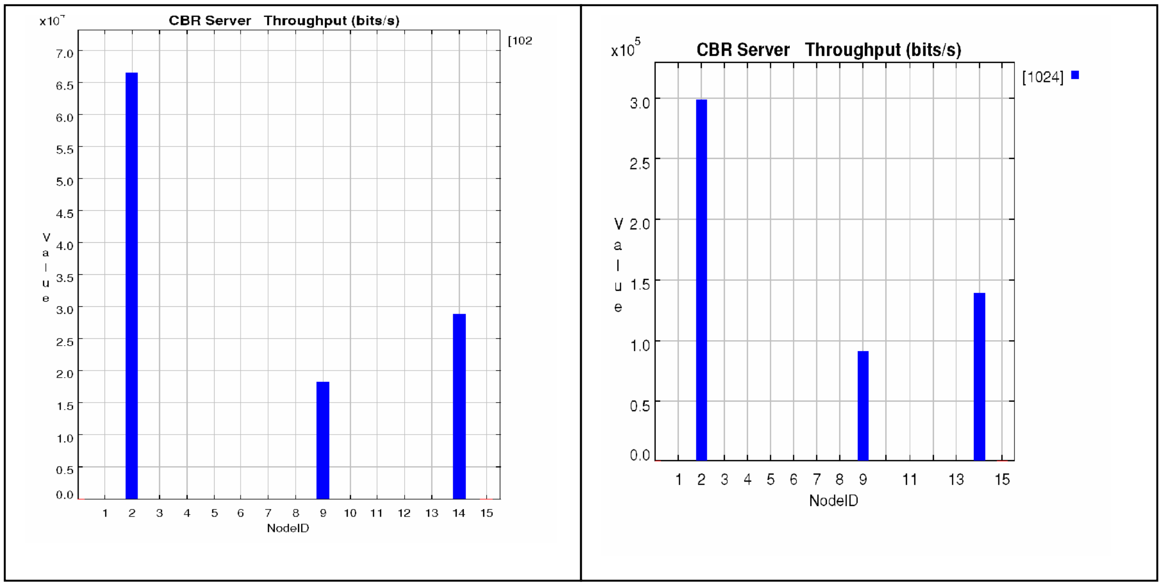



**Fig. 5.4.5.1 APs throughputs for 128Kbps CBR @54Mbps & 36Mbps**

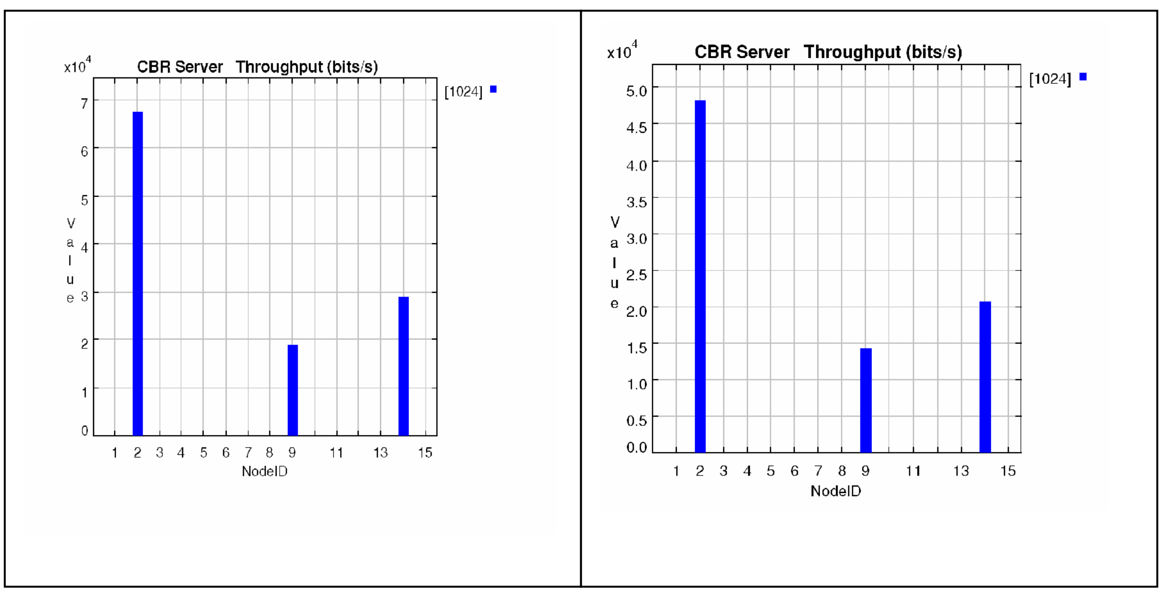



**Fig. 5.4.5.2 APs throughputs for 128Kbps CBR @11Mbps and 2Mbps**

**Results**The figure above shows the results for Constant Bit Traffic generation at 128Kbps which is the data rate for audio streaming. The actual results obtained using QualNet are shown for all the data rates 2,11,36 and 54 Mbps. The cumulative throughputs measured in the four cases are $8.4*10^4$ bits/s, $11.7*10^4$ bits/s, $5.2*10^5$ bits/s and $11.5*10^5$ bits/s.

## 5.5 Scenario with 4 APs

The figure below shows the actual scenario created in Qualnet with 4 access points (AP). The nodes 2 ,9, 15 and 14 are configured as APs. The node no. 2 is placed at Room No.6 in the ground floor, node no. 14 is placed at Room no. 6 in the first floor and node no.9 is placed in the Dining Hall and node no.15 is placed in one of the store rooms in first floor in the Guest House. All the four nodes act as access points and are made the server for file transfer and streaming audio applications. The throughput for each of the access points for different file sizes is obtained using Qualnet. Data rates are varied as in the above scenario. The parameters which are to be held constant over the whole scenario are the same as in the Scenario with 1 AP.

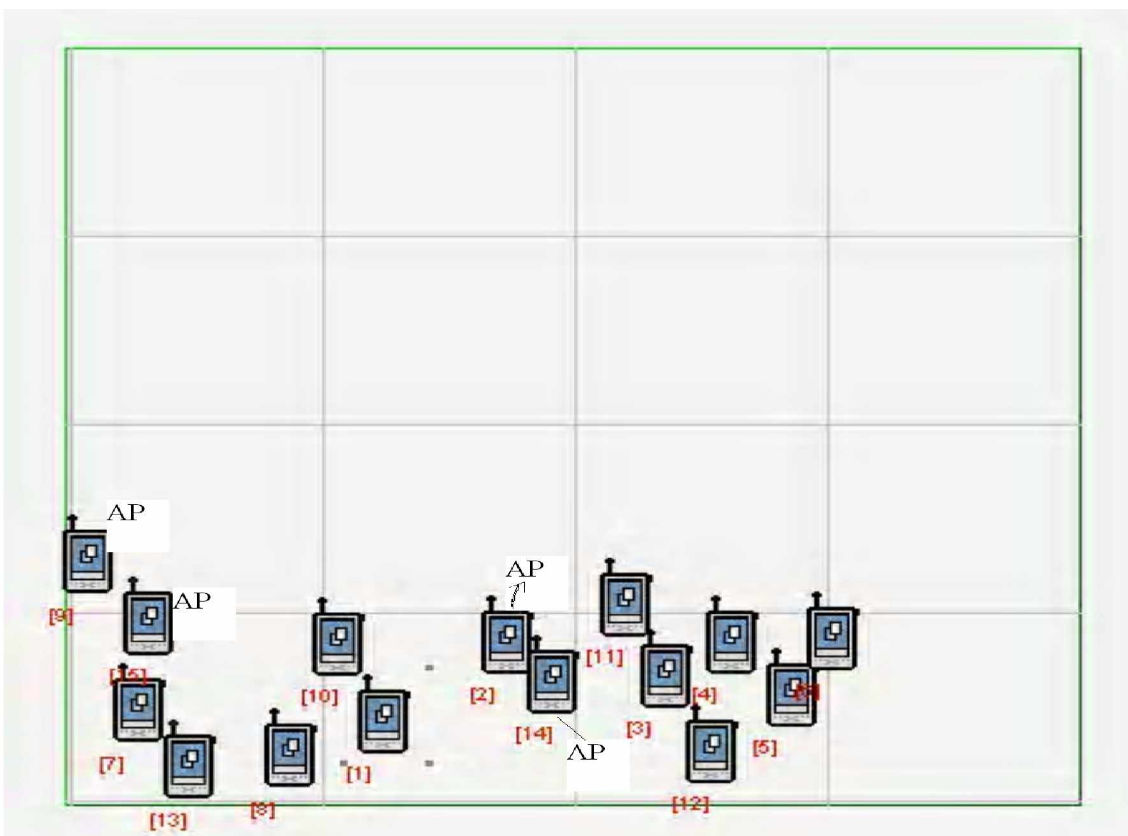



**Fig. 5.5 X-Y view of the Scenario with 4 AP**

### 5.5.1 Simulation 4.1

The protocol used was 802.11a and the data rate was kept at 54 Mbps. FTP throughput and Streaming Audio throughput was measured at 54 Mbps. We are interested particularly in the throughput of the servers i.e the access points(AP). The figures below shows the client and server throughputs measurements for various file sizes at 54 Mbps:

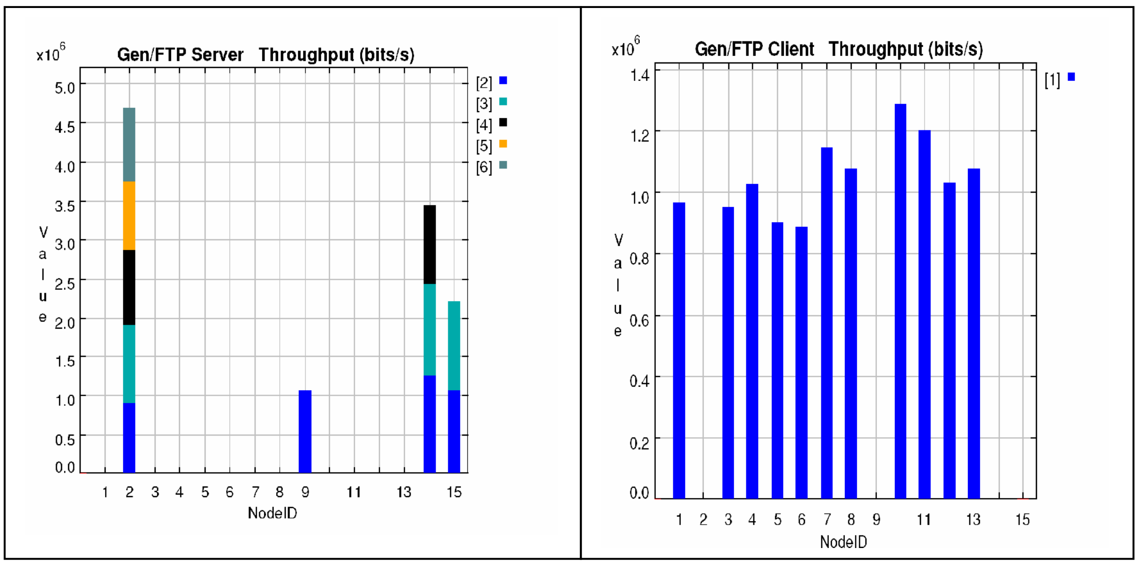



**Fig. 5.5.1.1 APs & Clients throughput for 0.5MB file**

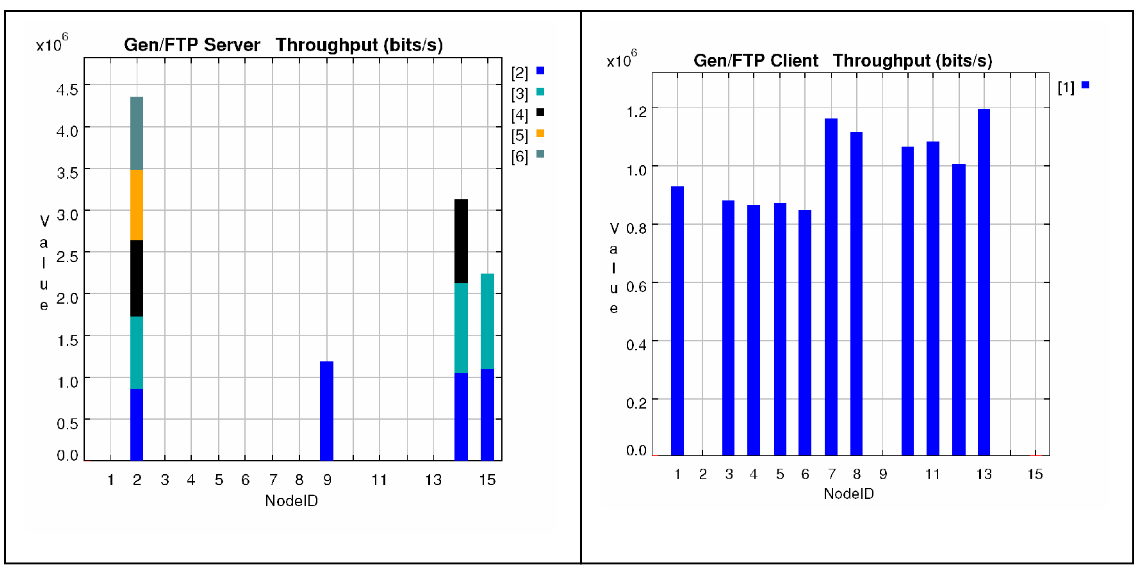



**Fig. 5.5.1.2 APs & Clients Throughput for 1 MB file**

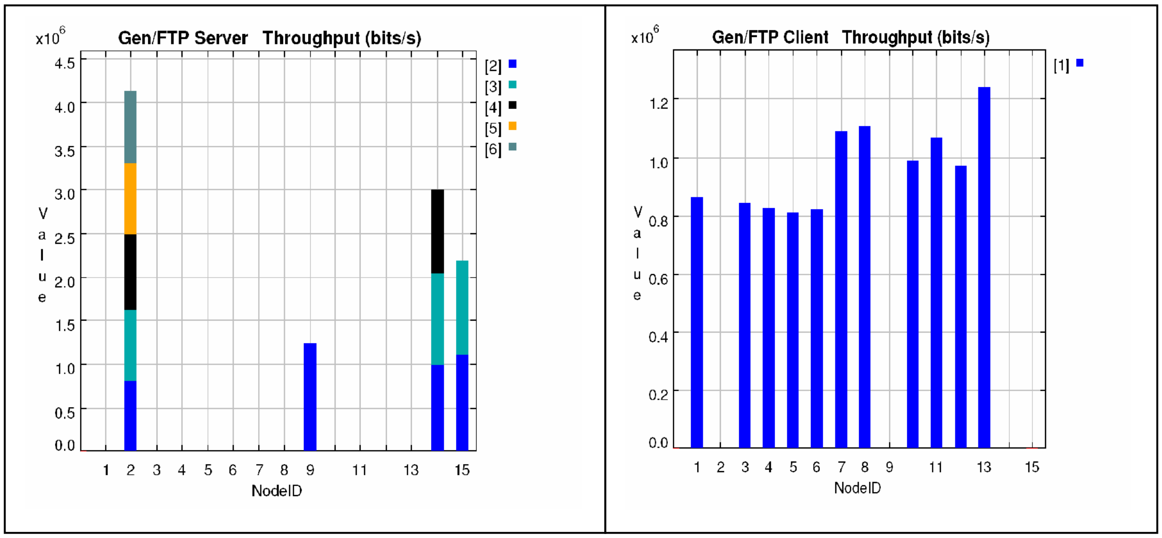



**Fig. 5.5.1.3 AP's and Clients Throughput for 2 MB file**

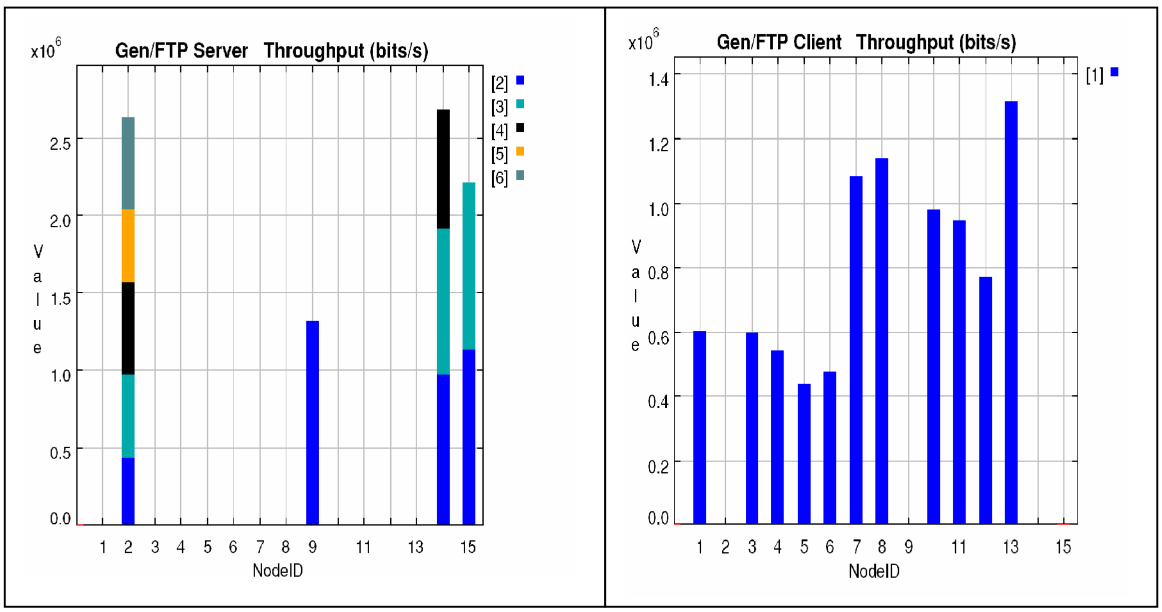



**Fig. 5.5.1.4 AP's and Clients throughput for 5MB and larger files**

**Results**: The above figures show the server(APs) and clients throughput in the scenario having 4 access points at a data rate of 54 Mbps. The total throughput obtained when a file of 0.5MB is being transferred is 11.5Mbps. The throughput obtained when a file transfer of 1 MB is taking place is 10.8Mbps, for a file transfer of 2MB the throughput value is 10.5Mbps. The saturating value of throughput is 8.8 Mbps, the throughput values for transfers of file sizes 5MB and larger.

## 5.5.2 Simulation 4.2

The protocol used was 802.11a and the data rate was kept at 36 Mbps. FTP throughput and Streaming Audio throughput was measured at 36 Mbps. We are interested particularly in the throughput of the servers i.e the access points(AP). The figures below shows the client and server throughputs measurements for various file sizes at 36 Mbps:

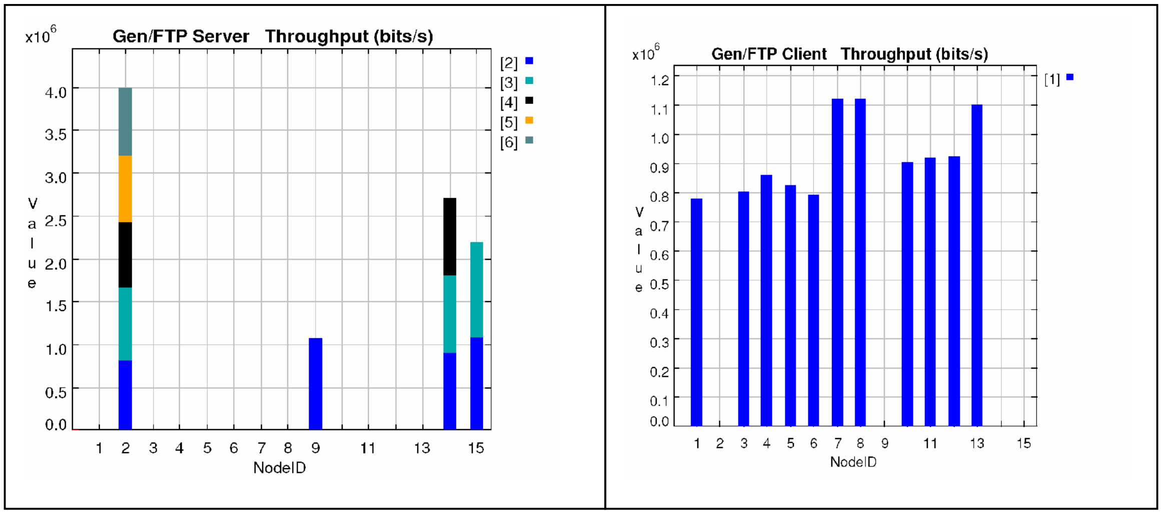



**Fig. 5.5.2.1APs and Clients throughput for 0.5 MB file**

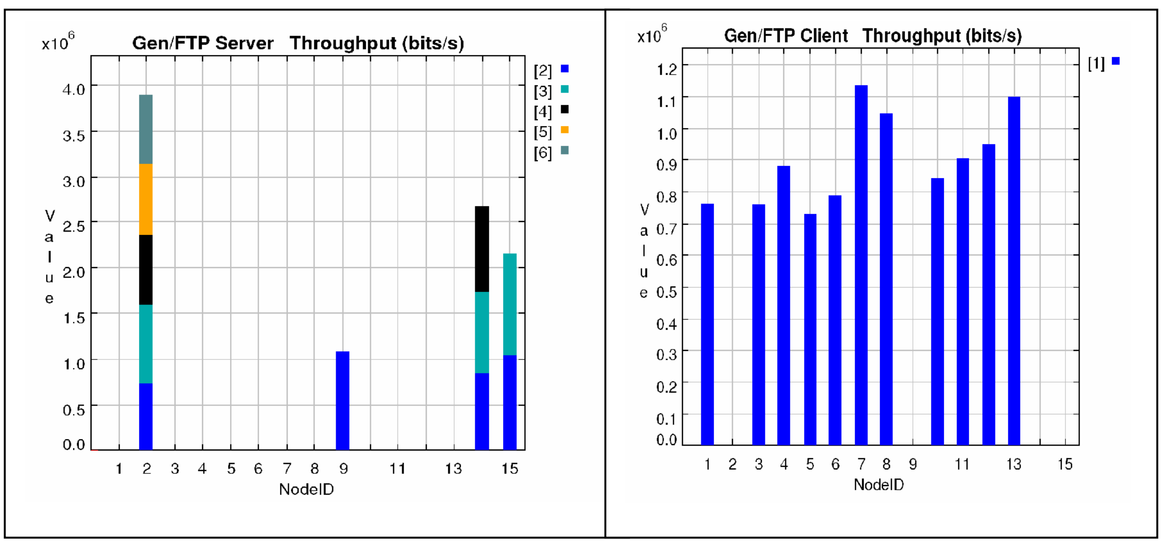



**Fig. 5.5.2.2 APs and Clients throughput for 1MB file**

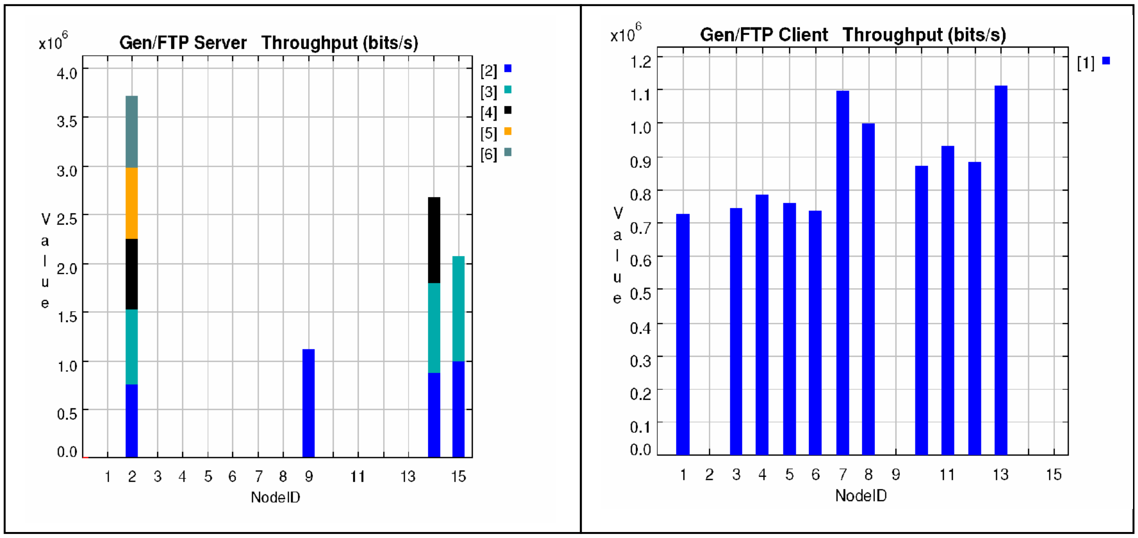



**Fig. 5.5.2.3 APs and Clients throughput for 2MB file**

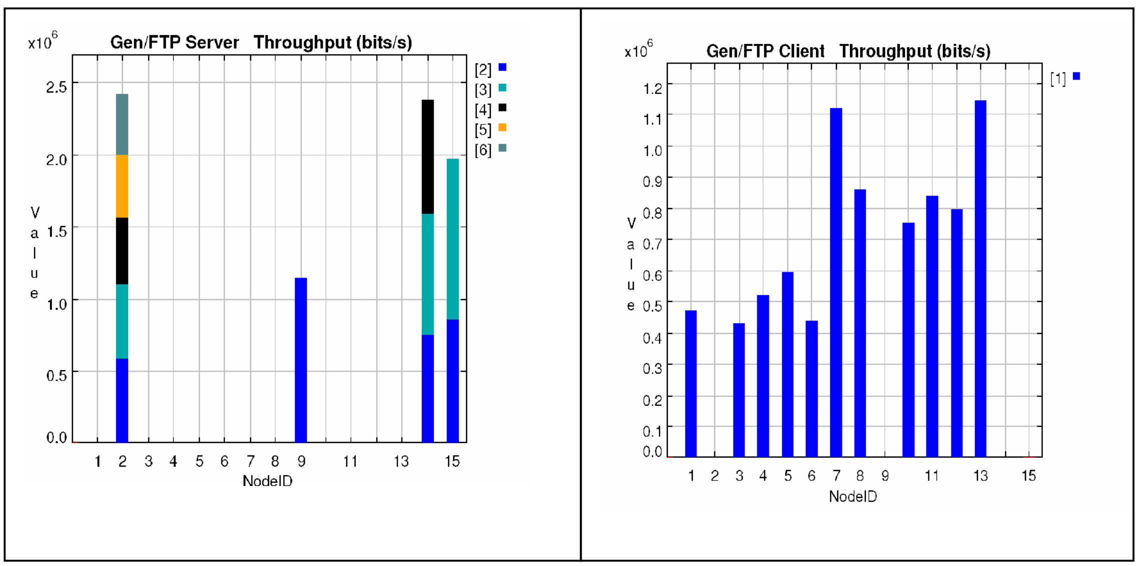



**Fig. 5.5.2.4 APs and Clients throughput for 5MB and larger files**

**Results**: The graphs obtained are an actual observation graphs obtained from Qualnet showing the server and clients throughput for varying file sizes at 36 Mbps. The total throughput of the APs when transferring a file of 0.5MB is found out to be 10.1Mbps. The total throughput value when 1MB of file is being transferred is 9.8Mbps, for 2MB of file the throughput is 9.5Mbps.
The constant value of the throughput was observed for files with size 5MB, 10MB and 20MB which can be seen from the graph is around 8Mbps.

## 5.5.3 Simulation 4.3

The protocol used was 802.11b and the data rate was kept at 11 Mbps. FTP throughput and Streaming Audio throughput was measured at 11 Mbps. We are interested particularly in the throughput of the servers i.e the access points(AP). The figures below shows the client and server throughputs measurements for various file sizes at 11 Mbps:

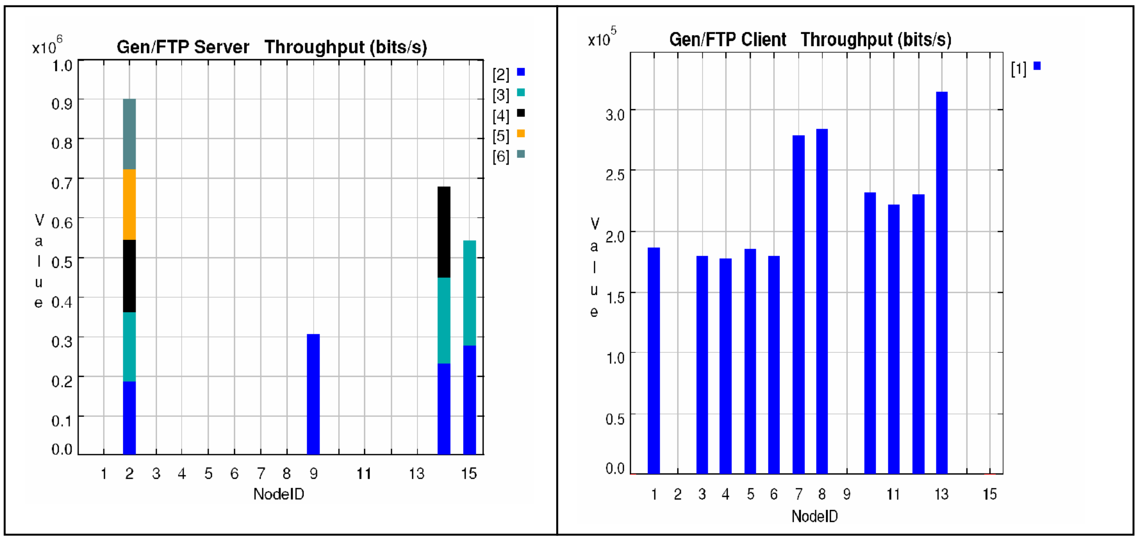



**Fig. 5.5.3.1APs and Clients throughput for 0.5MB file**

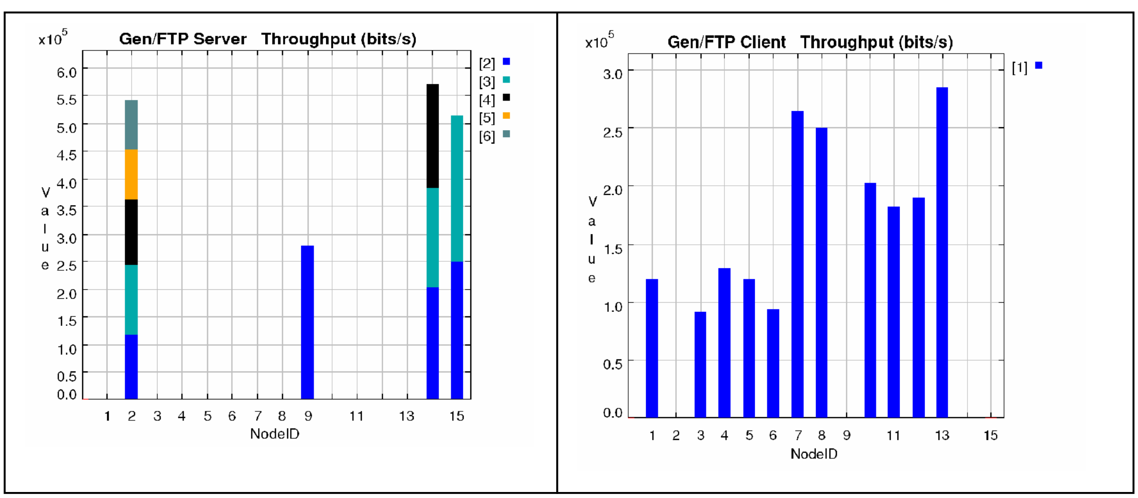



**Fig. 5.5.3.2 APs and Clients throughput for 1MB file**

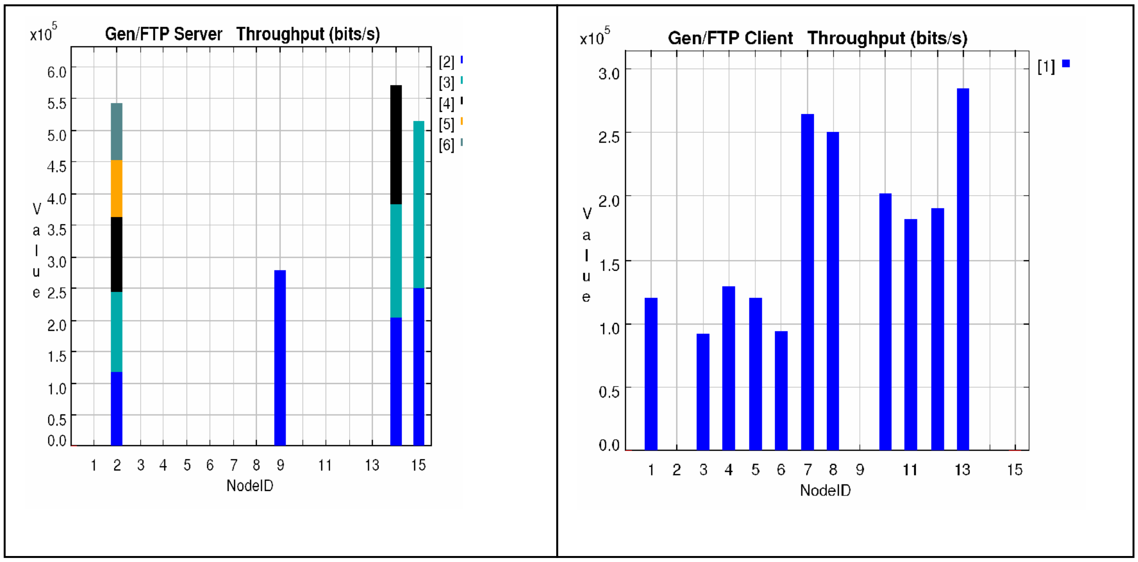



**Fig. 5.5.3.3 APs and Clients Throughput for 2MB, 5MB, 10MB**

**Results**: The graphs above shows the client and server throughputs at 11Mbps wireless link. The cumulative throughput of all APs for a file transfer of 0.5MB is 2.4Mbps. The total throughput for a 1MB file is 1.9Mbps and the saturating throughput is also 1.9Mbps the data rate supported by the APs. The aggregate throughput of 128Kbps CBR traffic is 1.16Mbps

## 5.5.4 Simulation 4.4

The protocol used was 802.11b and the data rate was kept at 2 Mbps. FTP throughput and Streaming Audio throughput was measured at 2 Mbps. We are interested particularly in the throughput of the servers i.e the access points(AP). The figures below shows the client and server throughputs measurements for various file sizes at 2 Mbps:

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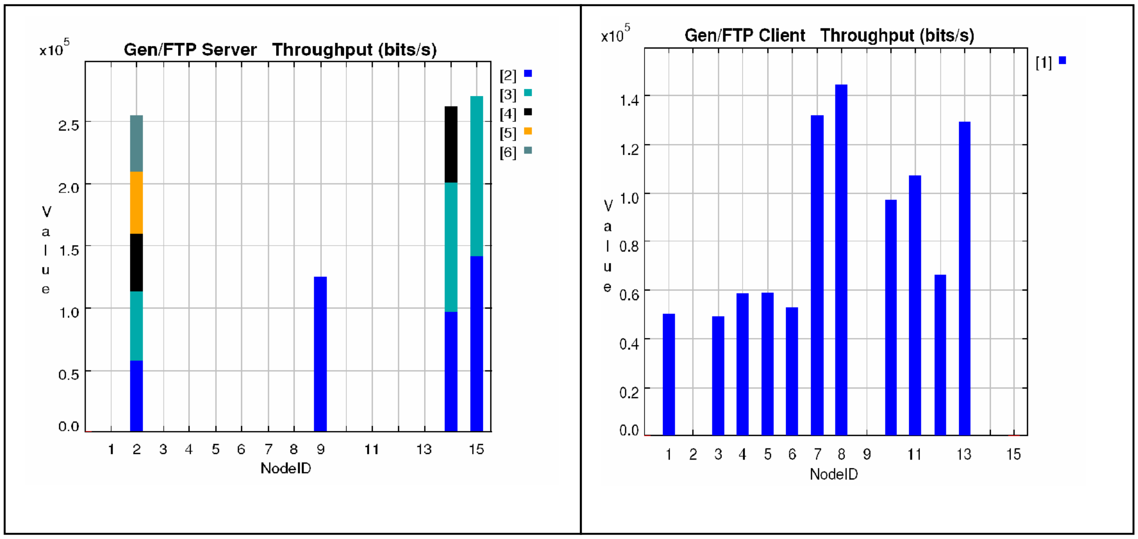


**Fig. 5.5.4.1 APs and Clients throughputs for 0.5MB, 1MB…..**

**Results:**

The graphs above shows the throughput measurements in Qualnet at 2 Mbps wireless link. The aggregate throughput measured is found to be 0.92Mbps which is same for all file sizes taken in our simulations.

## Streaming Audio

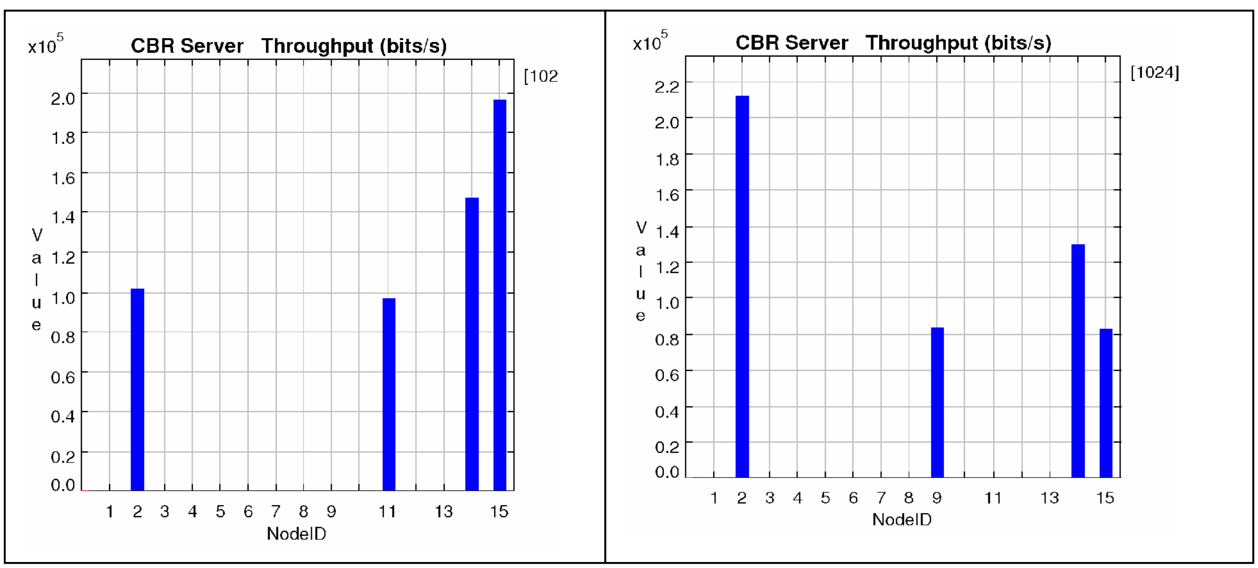


**Fig. 5.5.5.1. AP's Throughput for 128Kbps CBR @54Mbps and @36Mbps**

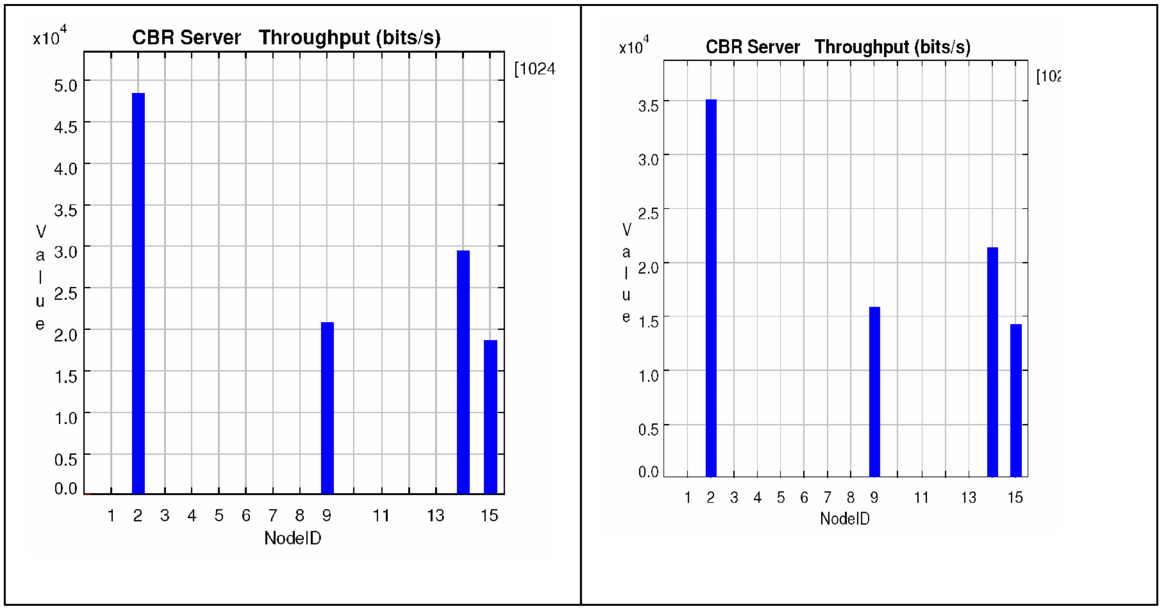


**Fig. 5.5.5.2 AP's Throughputs for 128Kbps @ 11Mbps and 2Mbps**

**Results**: The figure above shows the results for Constant Bit Traffic generation at 128Kbps which is the data rate for audio streaming. The actual results obtained using QualNet are shown for all the data rates 2,11,36 and 54 Mbps. The cumulative throughputs measured in the four cases are $8.6*10^4$ bits/s, $11.7*10^4$ bits/s, $5.1*10^5$ bits/s and $5.4*10^5$ bits/s.

# Chapter 6

# Conclusion

## Conclusion

The wireless service quality in the Guest House in NIT Rourkela was studied placing different number of access points at various locations in the guest House. Studying the performance of the network at different data rates and varying the file sizes we observe that 2 APs good for the whole scenario and can be placed in and around the centre of the guest house in the first floors and second floors. The actual results can be tabulated in as shown below:

Total throughput(in Mbps) using 1 AP

| | 2 Mbps | 11Mbps | 36Mbps | 54Mbps |
|---|---|---|---|---|
| 0.5MB | 0.92 | 1.96 | 10.2 | 12.0 |
| 1MB | 0.92 | 1.96 | 9.1 | 10.1 |
| 2MB | 0.92 | 1.96 | 7.7 | 8.9 |
| 5MB | 0.92 | 1.96 | 7.7 | 7.7 |
| 10MB | 0.92 | 1.96 | 7.7 | 7.7 |

Total Throughput(in Mbps) using 2 APs

| | 2Mbps | 11Mbps | 36Mbps | 54Mbps |
|---|---|---|---|---|
| 0.5MB | 0.92 | 2.12 | 9.8 | 12.2 |
| 1MB | 0.92 | 1.96 | 9.4 | 11.0 |
| 2MB | 0.92 | 1.96 | 8.3 | 10.1 |
| 5MB | 0.92 | 1.96 | 7.7 | 8.7 |
| 10MB | 0.92 | 1.96 | 7.7 | 8.7 |

Total Throughput(in Mbps)using 3 APs

| | 2Mbps | 11Mbps | 36Mbps | 54Mbps |
|---|---|---|---|---|
| 0.5MB | 0.96 | 2.72 | 11.0 | 11.5 |
| 1MB | 0.92 | 1.98 | 10.8 | 10.8 |
| 2MB | 0.92 | 1.96 | 10.2 | 10.4 |
| 5MB | 0.92 | 1.96 | 7.9 | 8.8 |
| 10MB | 0.92 | 1.96 | 7.9 | 8.8 |

Total Throughput(in Mbps) using 4 APs

| | 2Mbps | 11Mbps | 36Mbps | 54Mbps |
|---|---|---|---|---|
| 0.5MB | 0.92 | 2.42 | 10.0 | 11.4 |
| 1MB | 0.92 | 1.92 | 9.7 | 10.9 |
| 2MB | 0.92 | 1.92 | 9.2 | 10.6 |
| 5MB | 0.92 | 1.92 | 7.9 | 8.8 |
| 10MB | 0.92 | 1.92 | 7.9 | 8.8 |

The study of wireless service quality can be done in other buildings of NIT campus by just creating the scenario in Qualnet seeing the Autocad file.Various other applications can also be used for study like HTTP, Streaming Video and detailed analysis of the wireless service quality can be analysed.

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